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RESOURCE PARTITIONING BY ELK AND CATTLE: CYPRESS HILLS PROVINCIAL PARK, ALBERTA

BY

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF BOTANY

EDMONTON, ALBERTA

FALL, 1979

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Resource Partitioning by Elk and Cattle, Cypress Hills Provincial Park, Alberta" submitted by Peter George Lee in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

This study investigated elk (Cervus elaphus) and cattle in Cypress Hills Provincial Park, Alberta, over an intensive summer field study period in 1977 and 1978, to determine how these species partition the resources available to them. The niche dimensions of habitat (space), food and time were examined for these species in detail and more generally for the other ungulate species resident in the study area.

Habitat utilization was determined indirectly by fecal group counts and directly by observation both for general preferences and avoidances and for regional and annual changes. Directions of response towards general habitat types and individual features of the environment were evaluated. Use by both species was made of almost the entire spectrum of habitat types but elk were more ubiquitous in their distribution. The greatest habitat overlap was within non-forested areas and was not concurrent seasonally. While habitat utilization by elk seemed to be largely determined both by the presence of a preferred food supply and by the proximity of suitable cover, forage considerations played a more important role for cattle in determination of habitat selection. Habitat selection by elk during the winter period was highly variable and was dependent on climatic, especially snow, conditions.

Fecal fragments analysis showed that diets were highly similar at 73%. Grasses were the major dietary constituent for both ungulate species, contributing 77% of the diet of

cattle and 74% of the diet of elk on an annual basis. Festuca spp. (probably scabrella) were by far the most important food plant(s), contributing 63% and 71% of the diets of cattle and elk, respectively. Carex spp. were the second most important food items to cattle and plants of the Shepherdia -Eleagnus group to elk. Diet similarity was lowest during the summer. Studies of twig weight-diameter relationships revealed that although Ribes spp. and Potentilla fruticosa were the most plentiful shrub species, Salix spp. and Cornus stolonifera had the highest utilization. Standing crop and productivity of forb plants were found to be highly variable on an annual and regional basis - annual variations being dependent on the extreme variability of climatic conditions, characteristic of the study area. Standing crop in 1977, a dry year, averaged 82.3 g/m^2 and productivity in 1978, a wet year, averaged 162.8 g/m^2

Indices of niche overlap, using all the dimensions of habitat (space), food and time, were evaluated. Cattle and elk had the highest degree of niche overlap during nonconcurrent seasons - elk during fall-winter and cattle during the summer-fall period.

Distributions of moose and deer (mule deer and white-tailed deer together) were determined concurrently with the study of elk and cattle distributions and were compared to the latter using indices of overlap, crowding, selectivity and association. Moose had the highest degree of

habitat and spatial selectivity and elk had the lowest. The only other pair of ungulates besides elk and cattle that had an annual positive degree of spatial overlap was moose and deer, although there were some seasonal positive overlaps between various pairs. Elk and deer had a fairly high degree of diet similarity at 55%, with browse species being the most commonly utilized food group. Using indices of niche overlap, potential for competition was as high for elk and deer as it was for elk and cattle, although space was the dimension of highest overlap for the first pair while food was the highest for the second.

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Chapter 1: INTRODUCTION

I N T R O D U C T I O N

This study investigates resource partitioning by elk (Cervus elaphus) and cattle in Cypress Hills Provincial Park, Alberta. The field work was conducted during the summers of 1977 and 1978.

Resource partitioning is almost invariably implicated with the concepts of "niche" and "competition". However, to the extent that these two words seem confused in their uses in ecology necessitates their examination as they apply to resource partitioning studies of large ungulate grazing systems and to this study in particular. The inherent confusion of notions about niche and competition seem to be a matter of definition, logic and biological relevance. These all have theoretical as well as practical consequences that must be considered.

Theoretical Problems of Niche and Competition Concepts

There is a problem of definition. Whittaker et al. (1973) distinguished three historical senses of the word niche - Grinnell's (1917, 1924) and Miller's (1967) niche as the ultimate unit of habitat, Grinnell's (1928) and Elton's (1927) niche as a functional concept and Whittaker's et al. (1973) amalgamation of the "functional" and "place" concepts. The Eltonian concept is analagous to Hutchinson's

(1958) concept (Whittaker et al 1973) of set theory and is probably the most widely recognized today. Hutchinson proposed that the environmental variables affecting a species be conceived as a set of n-coordinates, which together define an n-dimensional hypervolume. Every point within the hypervolume is characterized by positive environmental conditions permitting that species to survive except in cases of certain interspecies interactive phenomena which result in exclusion of the species from their fundamental niche. Clarification of the concepts was not achieved by Odum (1971) who distinguished three aspects of niche - the spatial or habitat niche, Hutchinson's hypervolume niche and the Elton concept of trophic niche. However, the critical dimensions of niche may not be food resources but other limiting factors, and it is these latter which, when a resource shared by two species is in short supply, may operate to prevent their coexistence (Levin 1970). Vandermeer's (1972) definition related niche variables to within a community but did not define community. Whittaker et al (1973) proposed the word "ecotope" to represent the full range of environmental and biotic variables affecting a species and used "niche" to represent community and habitat to indicate separate communities. This reduction of niche to the old functional concept (intracommunity) becomes confusing when individuals of a species cross the sometimes subjective boundary between

communities and when their functional roles differ in different communities.

The reality of competition as a valid interpretation of the results of studies of resource partitioning among closely related species' assemblages seems to be subject to a resolution of the definition of competition. A plethora of definitions exist in the literature. Odum's (1971) definition as the interaction of two species striving for the same thing makes no allowance for the accepted theorem of Gause (1934) that competition can only occur in a limited environment. Odum also licenses future researchers to derive their own definitions by suggesting that his "broad in scope but precise in meaning" definition should be "subclassified" according to individual research needs. Miller (1967), modifying the definition of Clements and Shelford (1939), added ambiguity and nebulous restrictions by implying that competition occurs only on a trophic level. Birch (1957) found that competition had come to have at least four meanings in biology, ranging greatly in scope. Even in studies of large ungulate grazing systems, the definition has varied. Constan (1972), for example, used a certain definition concerning the grazing of the same area and similar plants while Julander (1958), Cole (1958), Buechner (1960) and Blood (1966) listed a somewhat different set of parameters Due to differing definitions it is difficult to evaluate research results. Situations may be described as

competitive in the light of one definition but not from other viewpoints.

Although species can theoretically interact in any combination of zero, negative or positive association (Odum 1971) the interaction which "is presumed to be a dominant force in biological evolution" is competition (Miller 1967). The major theoretical purpose of resource partitioning studies has been to obtain information on competition and the major theoretical purpose of competition studies has been to analyze its effects on co-existing species (Schoener 1974). Effects of a shorter term nature, such as limitations of species numbers was suggested by the mathematical experiments of Volterra and Lotka and effects of a longer term nature, such as evolution were first described by Darwin and later supported by Lack (1969) and others.

However, it is difficult to identify the process of competition since the differences of two species could potentially have arisen through some other agent of natural selection (Elton and Miller 1954). It is also difficult to prove the existence of competitive exclusion, an often assumed consequence of competition (Gilbert et al. 1952). Hutchinson (1948) does not assume the consequence of competitive exclusion and suggested that it may not apply when external factors limit species populations or when natural oscillations occur in the environment, preventing a permanent equilibrium. These oscillations were not

considered in the Lotka-Volterra models, which assumed a stable condition. Even if this assumption does occur, several authors have described conditions in which a stable equilibrium can be achieved by competing species (McClure and Price 1975, Johnson and Hubble 1975).

Therefore, if competition does not necessarily result in competitive exclusion, the relevance of the term becomes problematical and its useage may even obscure more important interactive pheromena. Also a source of some confusion is the amount of competition necessary to cause competitive exclusion. Estimates have varied from very rare competition (Levins and Culver 1971), to overlaps of 54% (MacArthur and Levins 1967), 70% (Rathcke 1967) and 80% (Brown and Leiberman 1973) without competitive exclusion.

The implication of competition as a negative interaction ignores the positive aspects of competition in terms of its selective value and increased diversity (Miller 1967).

Practical Problems of Niche and Competition Concepts

Although Hutchinson's (1958) niche concept is the one most widely recognized and has proved useful as a theoretical tool, he recognized three practical problems: (1) though the formulation suggests equal probability of survival of a species at all points up to the boundaries of its niche hypervolume, there will ordinarily be an optimum

part of the niche and suboptimum near the boundaries; (2) linear ordering of all environmental variables is assumed, although this is not in practice possible; (3) the formulation refers to an instant in time, but time must also be considered a variable.

Green (1971) noted three operational problems to the Hutchinson n-dimensional hypervolume niche concept and related competitive interpretations. (1) There is a practical limit to the number of environmental variables which can be measured, therefore it will always be potentially possible to miss the one which may shrink the niche intersection of two species or eliminate it (MacArthur, 1968). Therefore, even though it can be demonstrated that two species do not occupy the same niche, it can never be demonstrated that they do; (2) It is difficult to know a priori whether certain measurable parameters are redundant, invariant or irrelevant and any of these would change the orthogonal shaped niche axis to acute angles; (3) The large mass of multi-dimensional data collected was difficult to interpret. Difficulty of interpretation was demonstrated by Conley (1976) - "showing that two species utilize different parts of a distribution of a given resource is not a demonstration of the absence competition. Conversely, showing that two species utilize the same portion of a distribution of a given resource is not a demonstration of extant competition."

Sale (1974) felt that the measurement of fundamental niches was the only way to determine whether competition is occurring. The measurement of fundamental niches would require experimentally removing potential competitors, or exploiting natural situations in which competition is absent, or artificially increasing the supply of resources. Assuming the validity of these measures any of them is often beyond the resource constraints of short-term studies. There is a danger of using "static", short term data to infer competition when in another time, the competitive interaction may reverse (i.e. external factors such as snow cover may cause a once abundant resource to become scarce). Assuming that competition is not occurring between two species, it may not be that competition has never occurred, in fact, competition may have been the formative and active factor which created and maintained the separation (Miller 1967). Seasonal and annual phenologies on the part of the animals and the components will cause constant shifting of competition for specific resources. Intensity of interaction will also be an ephemeral factor (Conley 1976).

A major problem in any study of competition is the difficulty of measuring competition in the field. Niche overlap values have been proposed as measures of current competition and as indicators of past competition (Levins 1968, Schoener 1974), but in reality overlap may not necessarily equal competition and high overlap may exist

because competition is absent (Vandermeer 1972, Sale 1974).

Rationale for this Study

Even with all their resultant problems, the concepts of niche and competition cannot be ignored but should be considered for appropriateness in each individual study.

For the purposes of this study, Hutchinson's (1944) definition was applied - "niche is the sum of all the environmental factors acting on an organism". This definition implies the consideration of both intra- and intercommunity factors (as opposed to Whittaker's (1973) and Hutchinson's (1958) definition). The problem of defining competition in a meaningful way was less reconcilable even with Odum's (1971) license for individual definition; but for the purposes of this study, means the utilization of common resource(s) in short supply (this is closest to Birch's (1957) definition). This implies that competition can occur for a minimum of one resource either synchronously or sequentially and for any length of time. Consequently, there is no implication of competitive exclusion as the competitive phenomena (as here defined) may cease to exist or begin existing depending on external controls. This reduces the impact of competitive interpretations, therefore other interpretations and explanations of the interactions were attempted where possible.

Since it is impossible to identify or measure all the niche parameters that may be necessary to prove or disprove competitive interactions, or at least to investigate the important interactions, only a select few were chosen. Schoener (1974) and Hudson (1977) stated that niche differentation among coexisting species usually involved separation along the dimensions of habitat (space), food or time. It is these dimensions that received the emphasis in this study.

It is important to emphasize, however, that these delimitations of the concepts do not solve the problems of:

- potential incomparability with other studies due to lack of agreement on definitions.
- the biological relevance/irrelevance of the terms niche and competition.
- to what degree utilization of a common resource indicates competition.
- potential past or future interactions of a completely different nature than are occurring during this study due to external controls and interspecies adaptations.
- the impossibility of proving/disproving competitive interactions when there may always be more subtle patterns of resource utilization among the species.

Studies of resource partitioning among closely related species have not only theoretical (Schoener 1974) but also practical relevance (Hudson 1976). Practically, the

management of multi-species systems requires clear knowledge of the manner in which members of the community utilize and partition resources available to them. This information is basic to the sound management of such resources.

Cypress Hills Provincial Park is inhabited by six species of large ruminants - pronghorn antelope (Antilocapra americana), moose (Alces alces andersoni), mule deer (Odocoileus hemionus), white-tailed deer (O. virginianus), elk (Cervus elaphus) and cattle - of which elk and cattle are by far the most numerous. For this reason, and because elk and cattle are relatively close in their food preferences (based on other studies) the concentrated effort for investigation was on elk and cattle.

The fact that it can be demonstrated that two species do not occupy the same niche but it can never be demonstrated that they do (Green 1971), suggested utilization of a null hypothesis. In light of the problems with the concepts of niche and competition the present study was designed to test the null hypothesis that in Cypress Hills Provincial Park there is no niche differentiation between elk and cattle along the dimensions of habitat (space), food or time.

The information sought for a basis of good decisions and sound management of the large ungulate grazing system in Cypress Hills Provincial Park was specified in these objectives:

(1) to determine habitat preferences of elk and cattle

(2) to determine quantity of forage available

(3) to determine dietary preferences, overlaps and other potential conflicts between these two species

(4) to obtain information on interactions with other ungulates of the park.

Chapter 2: STUDY AREA

STUDY AREA

2.1 Location and General Description

The generally low, rolling topography of the southern Canadian plains of southeastern Alberta and southwestern Saskatchewan is interrupted by the Cypress Hills, where elevations average 350 m above the surrounding plains (Crickmay 1965). Elevations decline gradually from a western summit of 1,463 m (near Elkwater, Alberta), which is about 830 m higher than that of the City of Medicine Hat, 80 km to the northwest, to 1,000 m at Eastend, Saskatchewan. The three buttes comprising the Cypress Hills and separated from one another by broad valleys extend along an east-west axis for 132 km with widths averaging 16 km but reaching a maximum of 40 km and areal coverage of 2,590 km² (Newsome and Dix 1968 and Broscoe 1965) (see Fig. 2.1).

The study area consists of the northwestern section of the western butt, is comprised of Alberta's Cypress Hills Provincial Park (see Fig. 2.2),,is centered on 49° 39' N, long 110° 12' W and contains 19,900 hectares.

2.2 Geology and Topography

The bedrock geology has been described in some detail by Crockford and Clow (1965) and Vanhof (1965). Six stratigraphic units, the erosional remnants of an anticlinal

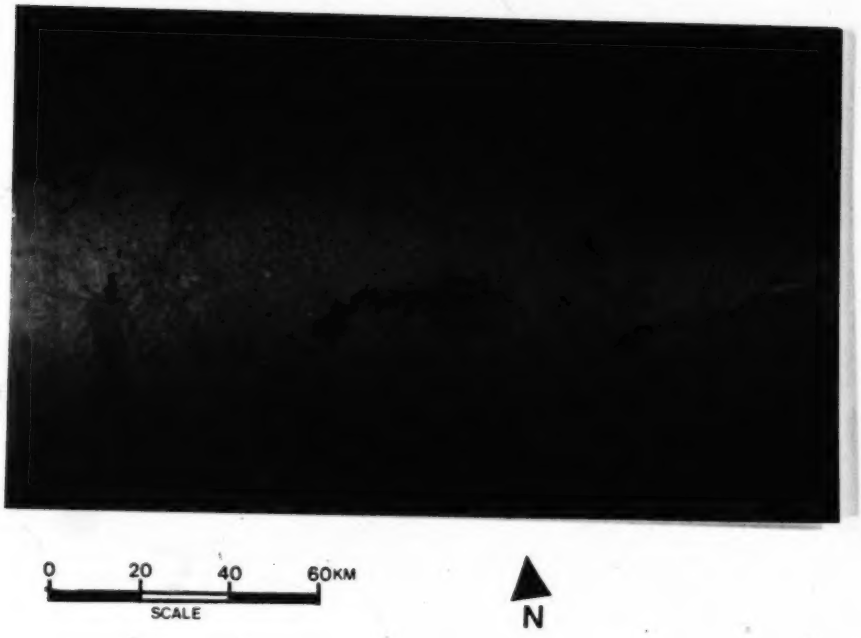

Figure 2.1 Landsat imagery of the Cypress Hills and area.

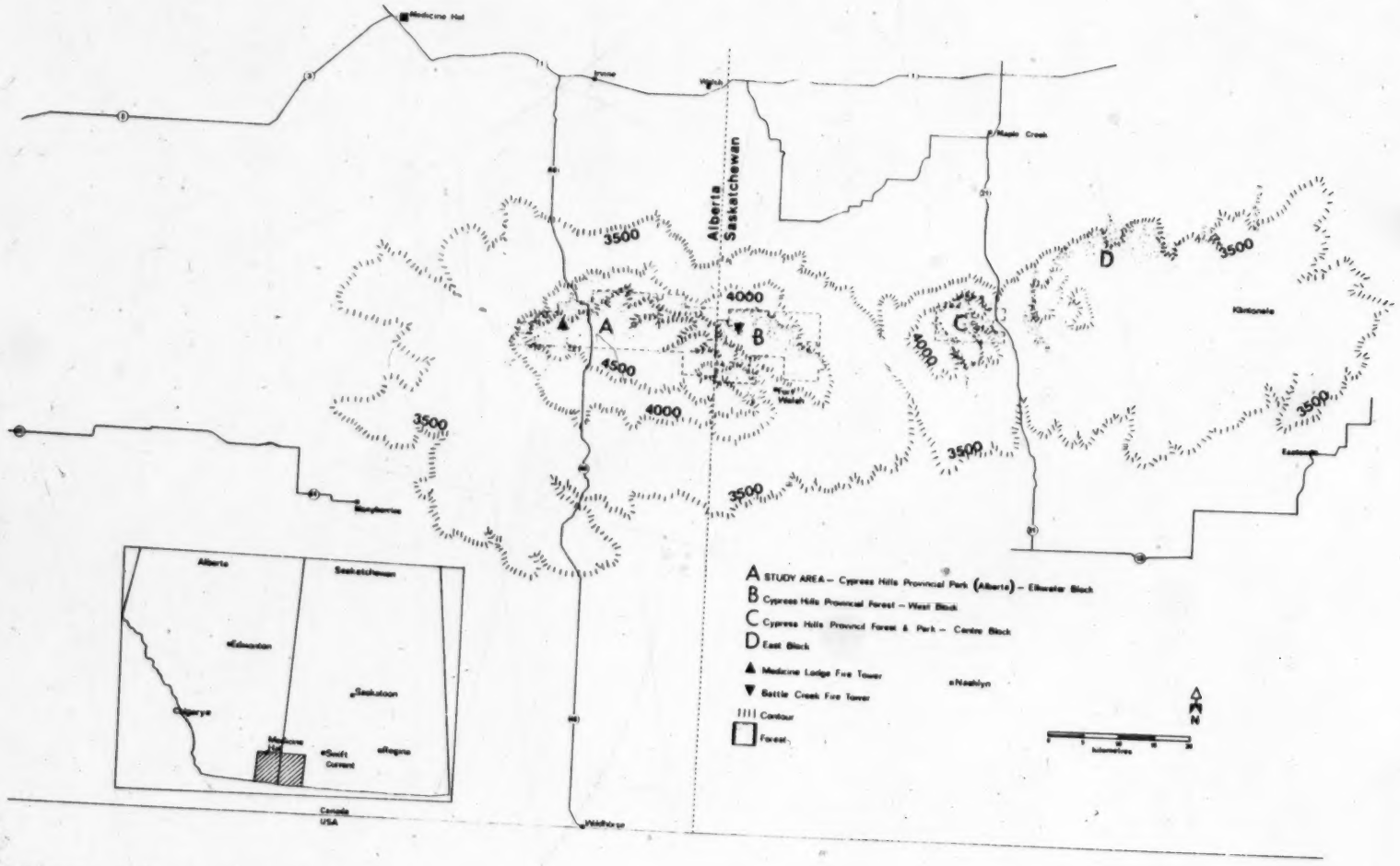

Figure 2.2 Map of the study area.

fold plunging eastward, rest on the Bearpaw Formation (Cretaceous 308 m thick). This formation extends well into the surrcunding plain where it is directly overlain by Pleistocene deposits. These units are, in ascending order: the Mesosoic Upper Cretaceous Eastend (35 m), Whitemud (0 - 11 m), Battle (2 - 9 m) and Frenchmen Formations (61 m) and the Tertiary aged Paleocene and Cligocene Ravenscrag (91 m) and Cypress Hills Formations (38 m) respectively. The hills have survived as an erosional remnant of the interior plains, because of the enfeebled lateral ercsive forces of the Cenczcic ancestors of the Misscuri and South Saskatchewan Rivers due to the position of the hills in relation to these fluvial forces (Crickmay 1965).

Surficial deposits capping the Cypress Hills Formation consist of unconsolidated Pleistocene deposits comprising glaciofluvial, glacial, aeolian and drift deposits (Westgate 1965). Loess (.3 - 2 m) is co-extensive with the unglaciated higher elevations of the plateau which projected 90 m above the Wisconsin ice sheet and comprised about 310 km^2. Final recession of the Wisconsin ice occurred earlier than 13 x 10^2 B.P. (Ritchie 1976). Recent aged deposits consist of alluvium, eroded slopes, colluvium and alluvial fan deposits (Cowell N.D.).

The modern topcgraphic aspect was formed mainly during the immediate post glacial period (Westgate 1965). The six major landforms present today are described by Cowell

(N.D.): plateau (or bench), slope/scarp, outliers, meltwater channels, flood plain, outwash apron and knob and kettle topography. The flat plateau surface not only inclines from west to east at about 5 m to the mile; it also inclines, though not quite evenly, from north to south. The southern political boundary of the park runs along the higher bench area, but the northern and western boundary, for the most part, lies north of the bold escarpments (215 - 260 m) which flank much of the northern and western edges of the Cypress Hills Plateau. Located on a drainage divide, the study area contributes waters to both Hudson's Bay and the Gulf of Mexico.

2.3 Climate

The climate of the prairie surrounding the Cypress Hills is characterized by relatively long, hot and dry summers and cold, sharp winters (Holmes 1969). Kendrew and Carrie (1955) described the climate of the Cypress Hills as continental with long, cold winters and cool, dry summers.

The plains south of the hills are semi-arid and average about 25 cm per year of precipitation (see Table 2.1 for Nashlyn), but precipitation increases to the west, north and east from this general area and with local topographic highs (such as the Cypress Hills).

Temperatures are also at their highest in this area, higher than other surrounding stations (except Klintonel)

and at greater elevations (i.e. Cypress Hills) (Table 2.2).

Meterological data are scanty and incomplete for the study area. Klintonel (Saskatchewan) is the only year-round station now operating within the Hills, but it is about 550 m below the highest point in the study area and so cannot represent the study area. A year round station was operated at the Battle Creek Ranger Station (Saskatchewan) from 1919 to 1931 and Kagis (1951) has summarized these data. Within the study area itself (Cypress Hills Provincial Park - Alberta) there is one summer meterological station (Medicine Lodge station), which has data from 1973 to the present for varying summer periods but generally from May to September. There is also the Battle Creek station in Saskatchewan which is about 1.6 km away from the study area and has data from 1974 for the months of July and August. These two stations are approximately 24 km apart on an east west axis (see Fig. 2.2 for locations).

The Cypress Hills receive more precipitation than other locations in the region. Holmes (1969) estimates that for the entire Cypress Hills, average annual precipitation exceeds 51 cm. The Battle Creek Ranger Station, (in the upper Battle Creek Valley, Saskatchewan) operated from 1919 to 1931, had an average annual precipitation of 47 cm with a range of 33 cm to 77 cm (Kagis 1951). Table 2.3 shows that for the period 1974 to 1978, the two stations in Cypress Hills received an average of 1.84 times the precipitation

Table 2.1. Mean precipitation (mm) for the period 1941 - 1970 (see Fig. 2.2 for locations) for selected stations near Cypress Hills.

	JAN	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Medicine Hat (653)*	22.6	18.3	19.3	25.1	38.1	63.5	38.6	39.4	33.0	17.0	16.3	16.5	347.7
Manyberries (923)	21.0	17.0	21.6	28.2	38.9	70.1	31.2	29.2	24.1	15.0	14.0	16.8	327.2
Nashlyn (945)	17.8	13.0	11.4	19.1	25.1	57.4	36.8	30.7	21.3	10.2	10.2	10.9	263.9
Klintonel (1067)	25.9	25.4	25.1	32.3	38.9	82.6	48.3	43.2	40.6	20.8	23.1	21.6	427.8
Swift Current (744)	22.1	17.3	18.3	26.2	36.1	78.0	51.8	46.0	35.1	20.6	19.3	19.1	389.9

*=Elevation in metres

Table 2.2. Mean temperature (°C) for the period 1941 - 1970 (See Fig. 2.2 for locations) for selected stations near Cypress Hills.

		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Medicine Hat (653)*	MD	-12.1	- 8.1	- 3.2	5.9	12.1	16.1	20.2	18.9	13.2	7.5	- 1.6	- 7.6	5.9
	MDX	- 6.4	- 2.4	2.4	12.6	19.0	22.7	27.9	26.6	20.3	14.5	4.2	- 2.1	11.6
	MDl	-17.8	-13.9	- 8.9	- .7	5.2	12.6	12.6	11.3	5.9	.6	- 7.4	-13.1	- 1.4
Manyberries (923)	MD	-12.6	- 9.2	- 4.8	5.9	12.1	16.1	20.2	18.9	13.2	7.5	- 1.6	- 7.6	5.9
	MDX	- 6.9	- 3.7	- 1.8	12.6	19.0	22.7	27.9	26.6	20.3	14.5	4.2	- 2.1	11.6
	MDl	-18.2	-14.8	-10.3	- .7	5.2	9.5	9.5	11.3	5.9	.6	- 7.4	-13.1	- 1.4
Nashlyn (945)	MD	-14.7	-11.9	- 5.6	3.9	10	14.3	18.3	17.2	10.9	4.8	- 4.4	-10.7	2.6
	MDX	- 7.9	- 4.2	.6	11.4	18.4	22.1	27.8	26.8	20.1	13.7	2.9	- 4.1	10.6
	MDl	-21.5	-19.1	-13.7	- 3.7	1.5	6.4	8.8	7.6	1.7	- 3.9	-11.7	-17.7	- 5.4
Klintonel (1067)	MD	-12.8	- 9.7	- 5.9	2.4	8.4	12.3	15.9	14.9	9.7	4.9	- 3.7	- 9.0	2.3
	MDX	- 7.3	- 4.0	- .2	9.2	16.1	19.7	24.7	23.8	17.7	12.1	1.9	- 3.7	9.2
	MDl	-18.3	-15.5	-11.7	- 4.4	.6	4.8	7.2	5.9	4.7	- 2.4	- 9.2	-14.3	- 4.6
Swift Current (744)	MD	-13.9	-10.6	- 5.9	3.7	10.3	14.8	18.7	17.7	11.8	6.1	- 3.7	- 9.7	3.3
	MDX	- 8.7	- 6.3	- 1.2	9.4	16.9	21.3	25.7	24.7	18.1	11.9	.9	- 4.8	9.0
	MDl	-19.0	-15.7	-10.7	- 2.1	3.7	8.5	11.7	10.5	5.3	.1	- 8.5	-14.4	- 2.6

MD = Mean
MDX= Mean maximum
MDl= Mean minimum
* = Elevation in metres

Table 2.3. Mean precipitation (mm) for the period 1973 - 1978 for Medicine Hat and two stations within Cypress Hills (See Fig. 2.2 for locations).

		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
M.H.		1.8	8.6	.8	30.7	5.8	124.0	6.6	37.3	19.6	17.5	24.4	19.1	296.2(-60.8)[10]
M.L.	1973					57.7	160.5	15.5	77.0	34.5	8.1[1]			
B.C.														
M.H.		14.5	17.5	27.7	44.7	53.1	45.2	23.1	48.3	7.6	5.1	1.5	7.6	295.9(-51.8)
M.L.	1974					163.8	67.3	79.5	80.8	22.6	5.6			
B.C.								54.1	74.2					
M.H.		7.6	20.6	36.6	53.3	86.9	70.1	37.1	34.3	23.1	14.5	26	25.7	435.8(+88.1)
M.L.	1975					87.6[2]	102.9	76.7	78.5	39.6				
B.C.								42.7	45.0					
M.H.		3.0	9.4	21.1	26.7	23.1	59.2	87.1	41.1	4.8	6.9	14.2	5.3	301.9(-45.8)
M.L.	1976					22.9[3]	156.8	63.7	60.5	23.5[4]				
B.C.								29.3	82.3					
M.H.		18	.7	6.2	6.7	80.5	19	41.2	40.2	39.3	1.6	18.0	31.1	302.5(-45.2)
M.L.	1977					127.7[5]	87.2	144.5	75.3	8.3[6]				
B.C.						60.4[7]	27.7	60.4	33.7					
M.H.		19.0	16.3	8.7	72.4	55.4	53.4	44.9	34.1	92.6	31.4	22.6	8.4	459.2(+111.5)
M.L.	1978					142.5[8]	65.8	130.4	98.4	153.6				
B.C.							30.5[9]	91.2	70.9					

1 Oct. 1 - 29
2 May 8 - 31
3 May 11 - 31
4 Sept. 1 - 10
5 May 5 - 31
6 Sept. 1 - 21
7 May 12 - 31
8 May 16 - 31
9 June 15 - 30
10 Deviation from 30 year average

M.H. = Medicine Hat
M.L. = Medicine Lodge Fire Tower
B.C. = Battle Creek Fire Tower

Table 2.4. Mean temperature (^{o}C) for the period 1973 - 1978 for Medicine Hat and two stations in Cypress Hills (see Fig. 2.2 for locations).

		JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
M.H.		-12.4	- 4.0	- 3.8	8.0	9.6	18.7	20.7	16.3	11.8	9.2	.5	- 2.3	6.0
M.L.	1974					5.1	13.5	16.1	12.1	8.2	6.9			
B.C.								18.5	12.7					
M.H.		- 8.4	-14.2	- 5.9	- .5	10.9	15.1	21.7	16.2	13.1	6.5	- 2.4	- 7.4	3.7
M.L.	1975					6.5[1]	10.4	17.0	11.5	9.0				
B.C.								17.5[2]	12.6					
M.H.		- 7.4	- 2.1	- 2.7	8.7	14.2	15.2	20.0	20.0	15.7	5.9	- 1.3	- 4.6	6.8
M.L.	1976						9.3	14.9	13.6					
B.C.								16.2	16.0					
M.H.														
M.L.	1977	-12.0	- .9	1.4	9.3	12.9	18.6	19.1	16.0	12.0	7.8	- 3.5	-12.7	5.7
B.C.						8.4	13.1	14.1	11.4					
							13.9	14.8	12.6[3]					
M.H.		-16.9	-13.1	- 2.4	6.3	12.1	17.2	19.5	17.6	14.0	8.5	- 6.0	-10.8	3.8
M.L.	1978					8.2[4]	12.3	14.4	13.2	10.4[5]				
B.C.								15.4	14.7					

1 May 8 - 31
2 July 4 - 31
3 Aug. 1 - 27
4 May 5 - 31
5 Sept. 1 - 21

M.H. = Medicine Hat
M.L. = Medicine Lodge Fire Tower
B.C. = Battle Creek Fire Tower

(2.18 x on Medicine Lodge tower and 1.48 x on Battle Creek tower) which fell in Medicine Hat for the months of July and August (which were the only months in which data had been collected for the two stations). Since approximately 23% of the annual precipitation falls in July and August in Medicine Hat, it is perhaps reasonable that the same percentage applies in the Hills. If so, the total annual precipitation in the study area (Cypress Hills Provincial Park - Alberta) would average about 62 cm for 1974 to 1978. In Medicine Hat about 52% of the precipitation occurs during May to August with June alone receiving 18% of the yearly precipitation.

Moisture budget in the Cypress Hills ranges from 10.2 cm to 20.3 cm. This compares to minus 27.9 cm at Medicine Hat and minus 18.3 cm at Swift Current (Longley 1968).

Using data collected between 1968 - 1972, Holmes (1969) estimates mean annual temperature in the Hills to be 2.5° C, with July the warmest at 14.8°C and January the coldest at -12.1°C. Data collected between 1919 and 1931 from the Battle Creek Ranger Station indicate July to be the warmest month with an average of 15°C, January the coldest and a mean annual temperature of 2.2°C. This mean annual temperature is 3.7°C below that of Medicine Hat. For the years 1974 - 1978 the average July temperature for the two stations was 15.9°C which was 4.3° below that of Medicine Hat. The average date of the last frost is June 18 and the

average date of the earliest frost is August 3, resulting in an average growing season length of 46 days (Holmes 1969).

At Medicine Hat, wind comes most often from the southwest and west. Winds come from a westerly direction 61% of the time on a yearly basis. The fall/winter months of October to March have westerly winds 66% of the time. In Cypress Hills, for the months of May to September, westerly winds occurred 65% of the time.

Macroclimatic variations within the study area are complex and substantial. For the period July to August, 1974 to 1977, there is a reduction of precipitation (32% reduction) and an increase in temperature (1.3° increase) from the western station (Medicine Lodge) to the eastern station (Battle Creek). These two stations are separated by 24 km and 144 m in elevation. There is also lower daily insolation and hence greater moisture retention on north facing slopes (Salt 1975).

There is also greater annual variation in climatic conditions and these variations have profound influences on the biotic resources of the study area. There is extreme variation in precipitation, temperature and duration of snow-free and frost-free periods. In some winters, permanent snowfall does not occur until mid or late December, while in other winters it may be late October. "Freak" spring snow-storms, with 30 - 80 cm of snow are not unusual in late April, and even less often, until mid-May (Salt 1975).

During some winters temperatures remain low for extended periods (Kramer 1971), in other years the lengths and numbers of severe weather spells are small. The difference between minimum and maximum snow cover varies radically, and there are a few virtually snowless winters on records. Frosts have occurred as late as July 12th and as early as July 17th (Holmes 1969).

The two years during which this study was conducted exemplifies this variation. In 1977 precipitation at Medicine Hat was only 87% that of the 30 year average. The precipitation in 1978 was 152% higher than in 1977 or 132% higher than the 30 year average. Within the study area, July and August precipitation was 125% higher in 1978 than in 1977. 1978 temperatures in Medicine Hat were 36% lower than the 30 year average and 33% lower than in 1977. This 1978 condition of lower temperatures and higher precipitation should be expected to greatly reduce the evaporative rate from that of 1977.

2.4 Soils

Greenlee (1979) has surveyed the soils of Cypress Hills Provincial Park. He recognized 22 map units of which 11 were soils of the Chernozemic order in the Canadian System of soil classification. This type was found associated with grassland communities or grassland-forest communities. Soils of the Luvisolic order were dominant in 4 map units and were

widespread in the valleys, on the escarpments that surround the plateau to the west, north and east and where lodgepole pine forests have encroached upon grassland areas. Soils of the Brunisolic order dominated 3 map units. They were commonly found on the fluvial gravels of the trough-shaped valleys which dissect the northern and eastern parts of the plateau. Solonetzic soils occurred in 2 map units and only a few small areas were found. These were in hummocky disintegration moraine and stream floodplains, in the extreme western portions of the park. One map unit was comprised of soils of the Regosolic order and these soils occurred on steep south-facing slopes. Soils of the Organic order constituted one map unit and were very limited in extent, being confined to the floodplains of streams and glacial meltwater channels. Soils of the Gleysolic order occurred along the margins of Organic soil areas.

2.5 Vegetation

2.51 Pre-Historic (Pre-European) Period

Ritchie (1976) provided a generalized account of vegetation compositions and their changes in the central plains following the retreat of the Wisconsin glacier and notes that a portion of the hills were nunatuks. However, floral and faunal compositions of the refugia remain problematical. Thompson and Kuijt (1976), in their study of

the Sweetgrass Hills of Montana, agree with Ritchie's account and postulate the reasons for segregation of cordilleran and boreal plant species following glaciation. Coniferous forests consisting of Picea glauca and Pinus contorta followed the retreat of the glacier and reached the Cypress Hills before a warmer climatic trend occurred (at about 10,000 B.P.). This resulted in expansion of grassland steppe vegetation and eliminated coniferous forests from all but the cooler elevated areas such as the Cypress Hills. Other montane species (such as Pinus ponderosa, Pseudo-tsuga menziesii, etc.) presumably did not reach the area. More cold-tolerant montane species (such as Abies lasiocarpa, Picea engelmannii , etc.) either did not reach the hills or became extinct because of lack of suitably high elevations during warm periods. Jungerius (1969) found that there have since been fluctuations in areal extent of forests and grasslands in the last 5,000 years with present climate favouring forest expansion.

Since the Hills are completely surrounded by semi-arid prairie and themselves contain considerable areas of grassland, they would be subject to many of the influences discussed by Dix (1964) concerning the formation and maintenance of grasslands. However, the incidence of fire may have been less than in the surrounding prairie since the hills were little used by Indian tribes adjacent to them (Scace 1972). As well, a cooler and moister climate would

also have reduced the incidence of fires. However, fire was still an important influence (Scace 1972, Newsome and Dix 1968). Two major fires in 1886 and 1889 removed much of the timber, and there was also a severe fire in 1893 (Newsome and Dix 1968). Only isolated trees and a few groves survived.

The effects of grazing by buffalo (Bison bison) on the grasslands is unknown although it is known that buffalo grazed extensively there. One of the early explorers of the region noted in 1880 the prominence of Lupinus argentea and Potentilla fruticosa in the western part of the hills "to the exclusion of other species" (Macoun 1882). But whether this is due to bison overgrazing or more mesic conditions is unknown.

2.52 Present Vegetation

The extirpation of elk and buffalo at the turn of the century removed the influence of wild ungulates on the vegetation resources of the park until the late 1950's, early 1960's when reintroduced elk populations had again increased significantly in numbers and when the introduced moose and native deer had, in combination, significant numbers. Cattle grazing has been extensive since the turn of the century. Early settlers harvested native grasses from bench areas and from valley bottoms. Timber was heavily utilized and by 1911, due to cutting and fires, most of the

forest cover had been denuded (Scace 1972).

Newsome and Dix (1968) perceive the present vegetation of the Hills as a "complex array of plant assemblages in which forest competes with grassland and in which forest and grasslands themselves are admixtures of several vegetational types". In the entire Cypress Hills area (Alberta and Saskatchewan) forests occupy only 20% of the landscape, grasslands about 70% and the remaining 10% is occupied by sedge meadows, fens, Salix carrs and associated aquatic communities (Newsome and Dix 1968). However, in the western section of the hills, the study area, these percentages shift - 55% forest, 40% grassland and 4% in lakes, wetlands and townsite (Gimbarzevsky 1955).

The forests of the Cypress Hills have been variously classified as "boreal forest outliers" (Rowe 1959) and "Boreal-Cordilleran transition forests" (Moss 1955). Breitung (1954) and removed for breeding purposes (Figs. 3.2, 3.4, 3.5). most meaningful due to the Rocky Mountain affinities of Pinus contorta var. latifolia, Picea glauca var. albertina and Betula papyrifera var. subcordata and the widespread distribution of the remaining tree species.

The four dominant tree species are Pinus contorta , Populus tremuloides, Picea glauca and Populus balsamifera (in descending order). Betula papyrifera var. subcordata and Acer negundo are rare and of little ecological significance (Salt 1975). The four main forest associations are the mixed

woods, the lodgepole pine, the white spruce and the poplar (Kerik 1971, Breitung 1954). Table 2.5 shows the aerial coverage of these associations (Gimbarzevsky 1954). The mixed wood association predominates the forested area (39.1%), the lodgepole pine, aspen and white spruce associations occupy 35.6%, 23% and 2.3% respectively. Pine dominated stands (pure plus mixed wood) occupy 53.3% of the forested areas, aspen 33.9% and white spruce 11.8%.

Newsome and Dix (1968), in their study of the Cypress Hills forests suggested that they exist as a vegetational continuum and are controlled by a variety of factors, chiefly alphagenic factors (the set of environmental, biological and historical conditions under which a stand is originated) as opposed to autogenic (temporal effects of conditioning imposed by the vegetation itself) or allogenic factors (effects of the physical environment). The relevance of alphagenic factors to the Cypress Hills forests lies in the fact that a majority of the forests are approximately 80 years old and have a pyric origin (Newsome and Dix 1968). Pine stands particularly, and aspen stands to a lesser degree, appear even-aged, but spruce ages vary widely (Gimbarzevsky 1954 - 61% of pine or 9,100 acres originated shortly after the 1880 - 1890 fires). Newsome and Dix (1968) found that the forested sites that are sufficiently homogeneous for phytosociological sampling are normally small (0.2 - 2.0 hectares) and usually have monodominant

Table 2.5. Aerial coverage (hectares) of various forest association in Cypress Hills Provincial Park (after Gimbarzevsky, 1954).

Species	Pure	Mixed	Total
Pinus contorta	3947 (35.6%)	2064 (18.6%)	6012 (54.3%)
Populus tremuloides	2535 (23%)	1221 (11.0%)	3753 (33.9%)
Picea glauca	250 (2.3%)	1054 (9.5%)	1304 (11.8%)
	6733 (60.9%)	4339 (39.1%)	11072 (100%)

canopies. The patterns of distribution of only certain understory species are not well distributed along canopy gradients. The mixed canopies exist as vegetational continuums between pure stands of Picea glauca, Pinus contorta, and Populus tremuloides. The ten most common understory species in each association are listed in Table 2.6. Many understory species seem directly associated with particular tree species but the associations are by no means constant or exclusive. Instead they express modalities of distribution. Topographic, physiographic and geographic influences modify the modal patterns. Lodgepole pine predominates on the northern escarpment; it commonly lines the crests and upper portions of south-facing slopes, and is a common element of parklands and savannas on the upper benchlands. Aspen is conspicuous along the northern escarpment, is common in all valleys that contain forested land and is abundant on the benchlands. Spruce achieves greatest prominence in deep valleys.

The prairies that occupy the surrounding plains and lower slopes of the hills are a series of faciations within the mixed prairie (Stipa-Bouteloua association). The grassland on the summit is considered as part of the fescue association (Coupland and Brayshaw 1953, Breitung 1954). The higher bench areas which are mainly occupied by the fescue association occupy about 75.3% (6810 ha) of the non-forested areas. Slopes, which are mainly of the Mixed Prairie

Table 2.6. Ten most common understory species in various forest associations in Cypress Hills (after Newsome & Dix 1968) (in descending order of frequency).

	PARKLANDS			SLOPES					WETLANDS	
	Pine and Aspen			Pine and Aspen						
Species	Pine		Aspen	Pine		Aspen	Aspen & Spruce	Spruce & Aspen	Spruce	Aspen
Amelanchier alnifolia						7				
Antennaria neglecta	5									
Arctostaphylos uva-ursi	1	6								
Arenaria lateriflora			8							
Arnica cordifolia				6	10			5		
Aster ciliolatus		4	9			2	4		6	3
A. conspicuous								6		
Calamagrostis rubescens				4	4		6	4		
Carex foenea		5	4							
Cornus canadensis				7	1			10	4	
Disposum trachycarpum						8		7		
Elymus glaucus			7							2
Equisetum arvense									1	
Erigeron glabellus	9									
Festuca scabrella	3									
Fragaria virginiana	4	1	2	10	5	6	1	8	5	9
Galium boreale	2	2	1			5	8	9		
Geranium richardsonii		9								6
Lathyrus ochroleucus	6	3	3	8	6	1	5			7
Linnaea borealis				2	3			1	3	
Oryzopsis asperifolia	8			9		3				
Osmorhiza spp.		8							7	4
Potentilla fruiticosa	10									
Pyrola asarifolia					9					
Rosa acicularis		7	6	5	7		10	3		
Rubus pubescens									2	
Schizachne purpurescens		10								
Smilacina stellata									9	
Spiraea lucida	7			1	2	9	7	2		8
Symphoricarpos albus			5			4	2			10
Taraxacum officinale									10	
Thalictrum spp.						10	9			5
Vaccinium caespitosum				3	8					
Viola adunca			10							
V. rugulosa							3		8	1

association, occupy about 18.4% (1664 ha) and lowland 6.3% (570 ha) (Gimbarzevsky 1955). Table 2.7 indicates the 10 most common species found in the fescue association for grazed and ungrazed sites throughout the park area. The great majority of the association in the park is grazed. Production estimates have varied substantially from 308.4 g/m² in 1968 (Dickinson, 1969) to 183.3 g/m² in 1974 and 208.7 g/m² in 1977 (Klumph 1978) (1968 was a very moist year while 1974 and 1977 were dry years). The result of past disturbances (such as grazing and harvesting of native grasses) is that "the grassland communities are mainly in a state of disclimax and there is no ecological interpretation of their boundaries. Instead, almost all of the present community types are differentiated by fences, by old fence-lines or by roads" (Salt 1975). The present communities have been defined and mapped by Robbins and Wershler (1971) with reference to their dominant and co-dominant species as "Fescue/Danthonia", "Fescue/Stipa", "Danthonia/Stipa" or "Potentilla/Fescue forb", etc. communities.

Table 2.7. Ten most common grassland species in Fescue Association in Cypress Hills Provincial Park (after Klumph 1978). (Descending order of cover.)

Ungrazed	Grazed
Festuca scabrella	Festuca scabrella
Carex spp.	Danthonia intermedia
Danthonia intermedia	Carex spp.
Allium textile	Festuca idahoensis
Agropyron subsecundum	Erigeron
Galium boreale	Agoseris glauca
Festuca idahoensis	Stellaria spp.
Stellaria spp.	Geum triflorum
Geum triflorum	Galium boreale
Potentilla fru ticosa	Potentilla fru ticosa

2.6 Wild Ungulates

There is a unique community of wild ungulates in Cypress Hills Provincial Park, which is characteristic of both grassland and forest habitats.

Pronghorn antelope (Antilocapra americana) are occasional and sporadic summer visitors to the study area. They are seen in the open grassland bench areas well away from tree cover, especially in the south part of the park. There have been no reports of antelope sightings in those plateaued areas which are physiographically and/or vegetationally separated from the surrounding plains. Therefore conflicts with the other ungulates and effects of antelope on the vegetational resources are considered inconsequential. As well, the park most certainly does not provide important habitat for antelope.

Moose (Alces alces andersoni) are generally believed not to be native to Cypress Hills (although see Dickinson 1968, England and DeVos 1969 and Scace 1972). A few moose may have been introduced to the West Block (Saskatchewan) in 1947 and it is known that in 1956 four moose from Elk Island National park (Alberta) were released in the study area (Cypress Hills Provincial Park - Alberta) (Dickinson 1968). By 1967, Dickinson estimated the potential population to be 119 (in both the Elkwater Block - Alberta and West Block -

Saskatchewan). Numbers are believed to have declined since 1970 as a result of a herd reduction program (Barrett 1972a) and an overall decline in the quality and quantity of browse (Dickinson 1968, Gudmonson 1975 a and b). Aerial surveys conducted in December, 1977 indicated a total moose population of 136 (104 in the Elkwater Block - Alberta and 32 in the West Block - Saskatchewan) (Alberta Recreation, parks and Wildlife 1977). Hunters removed 69 during the fall of 1978. In Cypress Hills the most preferred food species were found to be red-osier dogwood (Cornus stolonifera), saskatoon (Amelanchier alnifolia), trembling aspen (Populus tremuloides), willows (Salix spp.), pin cherry and choke cherry (Prunus pennsylvanica and P. virginiana). (Dickinson 1969, Barrett 1972a, Kowal 1977). In winter, moose prefer coniferous and deciduous forests in varying associations with suitable browse and avoid areas of lodgepole pine (poorly developed browse understory) and grasslands (too open) (Kowal 1977).

White-tailed deer (Odocoileus virginianus) and mule deer (O.hemionus) are native to the park. They are generally surmised (by local staff reports) to have been much more abundant in the pre-1960 period than the post 1960's (although both species were at a low at the turn of the century, Kramer 1972). Populations began to decline in the early to mid 1960's through a combination of disease (Chalmers et al. 1964), severe winters (1964/65, 1966/67)

and a possible increase in coyote. As a result, populations by 1968-70 were estimated by Kramer (1973) to have been one third to one quarter of former levels. It is also surmised that the deteriorating browse condition contributed to the decline and maintained them at low levels. As well, Kramer (1971) reported a further 30% per year decrease in mule deer populations between the fall of 1968 and spring of 1970 whereas populations of whitetails appear to have remained stable. Aerial surveys were conducted in February of 1978 and the surveyors spotted 110 whitetails and 471 mule deer in the study area[1]. Kramer (1971) noted that seasonal variations in habitat preference of both species do not vary greatly except in severe winters when white-tails have been noted to leave the hills in large numbers and exist in relatively open prairie/bushland for extensive periods.

The history of elk in the park, including their reintroduction has been discussed by Dickinson (1967), Scace (1972) and Keith (1977). Extirpation of elk perhaps began in 1871 when Cowie's party took 1500 elk hides from the Hills (Scace 1972) and ended in 1909 when the last one was supposedly killed (Keith 1977). These authors favour 1938 as the date of re-introduction on the Saskatchewan side (west Block), although there is controversy over the possibility of an earlier introduction in the 1920's (Webb 1959). Keith

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[1] These figures may be low because of difficulty of spotting deer from the air and the predilection of deer for fairly dense cover (Gudmonson 1975).

(1977) noted that the present race could be mixed but the original race was Cervus elaphus manitobensis (Salt 1975). Elk were first noted in the study area in the mid 1940's (Edwards 1974). Populations supposedly reached 250 - 300 animals by 1956 in West Block (Saskatchewan) and the study area (Elkwater Block - Alberta) but dropped to approximately 150 head by 1966 (Dickinson 1967). Comparatively reliable aerial surveys conducted during December, 1977, and February, 1978, indicated counts of 882 (487 in study area; 375 in West Block, Saskatchewan and 20 in Centre Block) and 869 (517 in study area and 352 in West Block), respectively. Hunters removed 249 in the fall of 1978 from the study area. Keith (1977) notes the importance of grassland habitats for wintering elk in the Hills as these areas provide major sources of winter forage. He notes the use of adjacent treed areas for providing suitable cover. Rumen contents were examined for 13 elk in October/early November and graminoids constituted 66%, forbs 17%, and trees and shrubs 17% (Keith 1977).

The extent of use by buffalo on the study area in historic times remains problematical although it is known that buffalo grazed there extensively (Spry 1968). By 1882 buffalo had disappeared from the Cypress Hills (Scace 1972).

There are no significant natural predators in the study area since the extermination of the plains grizzly (Ursus arctos horribilis) in the 1890's, cougar (Felis concolor) in

1914, and wolves (Canis lupus) by 1925 (Scace 1972).

2.7 History of Settlement and Livestock Grazing

The great complexity of land use and settlement history has been treated extensively by Scace (1972).

Before 1870, there were only a few transitory white visitors to the Cypress Hills, of which even fewer supplied written records. Before this period large parts of the hills were "buffer" zones between the traditional territories of a number of Indian tribes. As buffer zones the Hills received limited use. Only four written records of the Cypress Hills exist for the pre-1870 period - two of the Hudson's Bay Co. (i.e. Peter Fidler in 1800 and the Bow River Expedition in 1822-23) and two of government exploring expeditions (American Exploring Expedition of 1853 and the British Exploring Expedition led by John Palliser of 1859).

In 1872 four American whiskey trade posts were established in the Hills. As a consequence of the lawlessness contributed by the associated activities, the N.W.M.P. established a post at Fort Walsh (Cypress Hills - Saskatchewan) and maintained it from 1875 to 1883. This increased white activity together with large numbers of Indian and Metis led to a final breakdown of this buffer zone and to a "last refuge" for northern Plains Indians. This Indian and Metis occupation ended in 1883 with the extirpation of the buffalo and other grazing wild animals in

the hills and with the arrival of ranchers via the Canadian Pacific Railway into Maple Creek (Saskatchewan).

Agricultural activities probably began in the Cypress Hills in the late 1870's when 150 head of cattle arrived at Fort Walsh (1877) to supply the police. There were also about 40 horses and some small scale cropping along Battle Creek during this period.

The influx of ranchers was slow and steady and by 1900 a considerable ranching industry had been developed in the Cypress Hills area. Populations since 1900 around the hills have fluctuated widely but a sparse dispersed population has persisted. Ranchers first squatted and later took title to homesteads, sometimes penetrating deeply into the plateaued areas. Initially ranches were concentrated on the north side of the hills but within a few years were to be found on both sides. Native grasses were harvested from hayflats along creek bottoms and from the fescue grasses of the benchlands.

Many of the ranchers using grazing lands became members of stock associations that were established to regulate private grazing on public lands. Cattle drifted with little management between roundups. The timber, water and wildlife resources were also heavily used. By 1893 there were reports of timber getting short due to overcutting and fire.

During the period 1906 - 1930 the Cypress Hills were a federally managed forest reserve and a small national park (in Saskatchewan East Block). The reserve established in

1906 covered those areas which did or potentially could produce timber. This area was gradually expanded to include some adjacent grasslands and after 1911 the reserve extended from the Elkwater Block (in Alberta) into the West Block and Centre Block (both in Saskatchewan). During this period there was intensive fire suppression management, lumbering and treeplanting, grazing and haying. There are no existing records which would accurately identify the numbers of domestic stock grazed seasonally or the amounts of hay cut during this period. Permits for grazing were first issued in 1913 and by 1918-19 six stock associations were formed of which three existed in Alberta Cypress Hills - Medicine Lodge, Battle Creek and Fox Stock Association. Detailed records of numbers of members and of stock numbers grazed on the individual stock association areas until 1930 are unavailable. However from the period 1918 - 1923, numbers of livestock grazed in the entire Cypress Hills (Alberta and Saskatchewan) varied from 5,800 to 10,200 (of which 30-43% were horses).

The transfer of natural resources to Alberta and Saskatchewan occurred in 1930. Most of the Elkwater Block was administered from 1930 - 1949 by the Provincial Forestry Administration of the Department of Lands and Mines and then its reorganized Department of Lands and Forests. Although the Department decided how many permits might be issued for grazing in any year, most of the management continued to be

under the immediate supervision of the three stock associations. Annual stock numbers varied between 150 and 530 horses and 2,100 and 3,200 head of cattle. In most years there was almost complete utilization of the forest reserve range over the entire Cypress Hills Forest Reserve (in Alberta). In 1947 the Department of Lands and Forests transferred the administration of a small portion of the Elkwater Block (112 acres) to the Provincial Parks Board as a Provincial Park and in 1951, extended the Cypress Hills Provincial Park to include all land held in the forest reserve (which area has remained relatively the same, with some minor additions).

Since the establishment of a provincial park in Alberta, the grazing activities of the three stock associations and individual permittees have continued as before.

Accurate records of stock in the park were not kept until 1977 (see Table 2.8). Before this period, only in 1965 was relatively accurate records kept. However in 1951-53 Gimbarzevsky (1955) reported there were 3,300 head of stock in the park and in 1954 there were 3,433 head and in 1971 Nalbach et al. (1971) estimated 4,000 head.

For other years, there are only the individual associations records which provide numerical accounting. The associations have varying methods of recording numbers of stock or animal units in the park and so the records are not

Table 2.8. Cattle stocking rates for various periods in the three major stock associations in Cypress Hills Provincial Park.

	BATTLE CREEK					FOX STOCK					MEDICINE LODGE					
	Yrlgs.	Other Cattle	Horses	AU's[1]	AUM's	Yrlgs.	Other Cattle	Horses	AU's[1]	AUM's	Yrlgs.	Other Cattle	Horses	AU's[2]	AUM's	TOTAL AUM's
1952							788	28								
3							800	30								
4							806	25								
5							805	25								
6							-	-								
7							-	-								
8							813	23								
9							813	-								
60							872	24								
1							873	18								
2							728	17								
3							730	14				1054				
4							870	13				1198				
5	799	1126	14	1680	3216[3]		871	-		4247[3]		1230			4070[3]	11533[3]
6	651	1041	-	1475		352	600	6	874			1236				
7	1424	1083	2	2035		325	617	6	871			1240				
8	940	1134	-	1761		266	650	11	867		821	1314	21	1274		
9	1206	1060	-	1864		317	617	12	873		877	1303	17	1272		
70	503	1390	-	1725		272	648	13	874		973	1147	28	1270		
1	787	1651	4	2182		397	590	12	873		810	1310	30	1269		
2	1062	993	5	1709		355	619	12	873		773	1350	26	1205		
3	1315	994	3	1876		239	701	7	840		666	1345	29	1200		
4	1067	1078	8	1801		239	701	7	870		797	1314	29	1241		
5	-	-	-	-		239	702	7	871		1007	1109	27	1099		
6	578	807	7	1203		239	712	0	871		1017	1056	28	1248		
7					6261.4[4]	313	657	4	871	3783.6[4]	744	1220	26	1200	5211.2[4]	15256.1[4]
8					3579.6[4]					2766.3[4]					4084.9[4]	10430.8[4]

1 My AU's based on Stock Association records
2 Stock Association estimate
3 H.W. Thiessen et al., Cypress Hills Grazing Investigation (1966)
4 Official Parks staff count

comparative between associations nor between periods of time. However, for the three years of relatively accurate records (1965, 1977, 1978) the average Animal Unit Month's used per year was 12,407, with variations of 146% between the highest and lowest years. Medicine Lodge Stock Association had the highest average numbers (4,455 AUM's), then Battle Creek S.A. (4,352 AUM's) and lastly Fox S.A. (3,499 AUM's), but the order varied from year to year.

For the years in which there are records, Battle Creek S.A. has the greatest fluctuations in numbers (148% in AUMs from the highest to lowest years), then Medicine Hat S.A. (116%) with Battle Creek showing little variation (at 104%). There seems to be no observeable trend in terms of increasing or decreasing numbers over these years on records and most likely this situation has remained relatively constant since at least 1920. Fluctuations are probably caused by such external controls as economics (i.e. market conditions and trends). About 4% of total park area is excluded from grazing (of which one half of this is water bodies).

Chapter 3: HABITAT UTILIZATION

HABITAT UTILIZATION

3.1 Introduction

The adopted approach in studying habitat preferences of ungulates has often been to classify an area into a number of habitat or vegetation types (based on purely subjective designations or more formal phytosociological techniques) and then to describe the animals' distribution within these types, either by direct census or by counts of sign left by the animal. Other researchers have attempted to define specific features of the environment which might influence animal distribution; sometimes the two approaches are combined.

Most research on elk has been in mountainous areas where major seasonal movements occur (Washington - Schwartz and Mitchell 1945, Wyoming - Anderson 1958 Idaho - Dalke et al. 1965, Montana - Knight 1970, Yellowstone National park - Craighead 1972). However, nonmigratory herds[2] have been studied in Yellowstone National park (Martinka 1969, Craighead et al. 1977), Riding Mountain National park (Blood 1966) and Elk Island National park (Cairns 1976). These studies indicate that differences in vegetational types and

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[2]Non-migratory herds in this sense means that there are no traditional mass movements on a semi-annual basis to completely different areas; however there may be habitat preference changes or occasional mass movements in unusual years (Craighead et al. 1977).

physiognomies precludes transposing habitat preferences from one area tc another. There may be complex and even subtle differences in environmental characteristics that have profound effects or preference patterns.

Few researchers have actually determined seasonal elk use of various habitat types as most research has been of the observaticnal type (Stevens 1966, Eustace 1967, Gordon 1968, Mackie 1970, Kcmberac 1976). The difficulty of observing elk within fcrest types, for example, indicates that cbservational data do not reflect actual use levels on a comparable basis but severely biases observations to the mcre cpen areas.

Comparative studies of habitat preferences of elk and cattle have been made by Julander and Jeffery (1964), Blood (1966), Stevens (1966) Eustace (1967), Gordon (1968), Mackie (1970), Knowles (1975) and Komberac (1976). These studies reveal elk to be more catholic than cattle in their use of different habitats and environmental features, and to have a higher preference for forested habitat and steeper slopes than cattle.

In this chapter habitat utilization of elk and cattle is described both in terms of available vegetational types and of specific features cf habitat, with consideration of annual and regional changes in preferences.

3.2 Methods

3.21 Vegetation Types

The theoretical problem with an *a priori* classification (subjective or otherwise) of vegetation (habitat) types is that the features used to classify the types may not be those features inducing a response in the animal. As well, classification only involves biotic (i.e. floristic) parameters, and almost invariably ignores abiotic parameters (i.e. slope, aspect, etc.).

As well as this general theoretical problem, there is also a specific classification problem related to the phytosociological characteristics of the Cypress Hills (see Section 2.6). Many of the dominant plant species have a rather ubiquitous distribution, or at least exhibit modalities of distribution from which gradual changes in prominence occur. Distinct demarcation of vegetational types could be considered meaningless or at least considered to disregard large ecotonal areas.

However, the practical advantage of classifying habitat types is that comparative areal relationships to gross vegetational features can be identified. Definite locales of preference or avoidance can be determined even if the exact reason for the distribution remains problematical.

For these reasons, two habitat classification systems were used. First, the broad-scale mapping units based on canopy coverage and developed by Parks Division (of Alberta Recreation, Parks and Wildlife) were used. Secondly, the major forest vegetational types of Newsome and Dix (1968), which were delineated by ordination techniques, were used.

Newsome and Dix's (1968) vegetational types were distinguished in the field by a reconnaissance method (Franklin et al. 1970, Douglas 1974). Crown cover of each vascular understory species within 15 m diameter plots (the centre of which was the same centre point for the fecal group microplots) was recorded using the cover classes of Daubenmire (1959). The number of plots totalled 912. In forested stands, all trees within the circle were counted by species and diameter at breast height was determined.

3.22 Habitat Utilization - General Preferences

The eastern half of Cypress Hills Provincial Park was chosen for the establishment of fecal group transects. Its choice was based on a May, 1977 reconnaissance of the area in which 84% of all the elk sightings were sighted in this one area. Within this area, the Viewpoint Plateau (see Fig. 3.1 for location), and surrounding forested habitats was chosen as the concentrated study area. This area contained 33% of the elk sightings, it was easily accessible, it was well noted for common sightings of elk all year long, it was

historically widely used by cattle and it is centrally located in the park. Approximately one-half of the transects were located in this concentrated area and one-half located throughout the rest of the eastern part of the park.

Seasonal habitat utilization by elk and cattle was determined by quantifying fecal groupings within 15 m^2 circular plots spaced at 30 m intervals along straight line transects.

Choice of plot size and distance between plots was based on various reviews and studies and considered the efficiency and reduced biases of small plots (Neff 1968), predicted consistency of results (Smith 1964), time spent in travelling and locating the different plots (Cairns 1976, Salter 1978), and the gross areal characteristics of plant communities in the Cypress Hills (Gimbarzevsky 1955). Transects were chosen to run diagonally across drainages (Robinette et al. 1958). The length of transects was based on the average distance from the grassland benches to the valley bottoms (i.e. about 900 m). Thirty transects were established - sixteen in the Viewpoint Plateau area were located by a stratified random method; fourteen in the rest of the eastern park area were subjectively located from aerial photographs. The transects and plots were permanently established by a centre-point spike projecting about 5 cm from the ground surface. The plot boundary was delineated at each visit by the use of a looped rope of appropriate radial

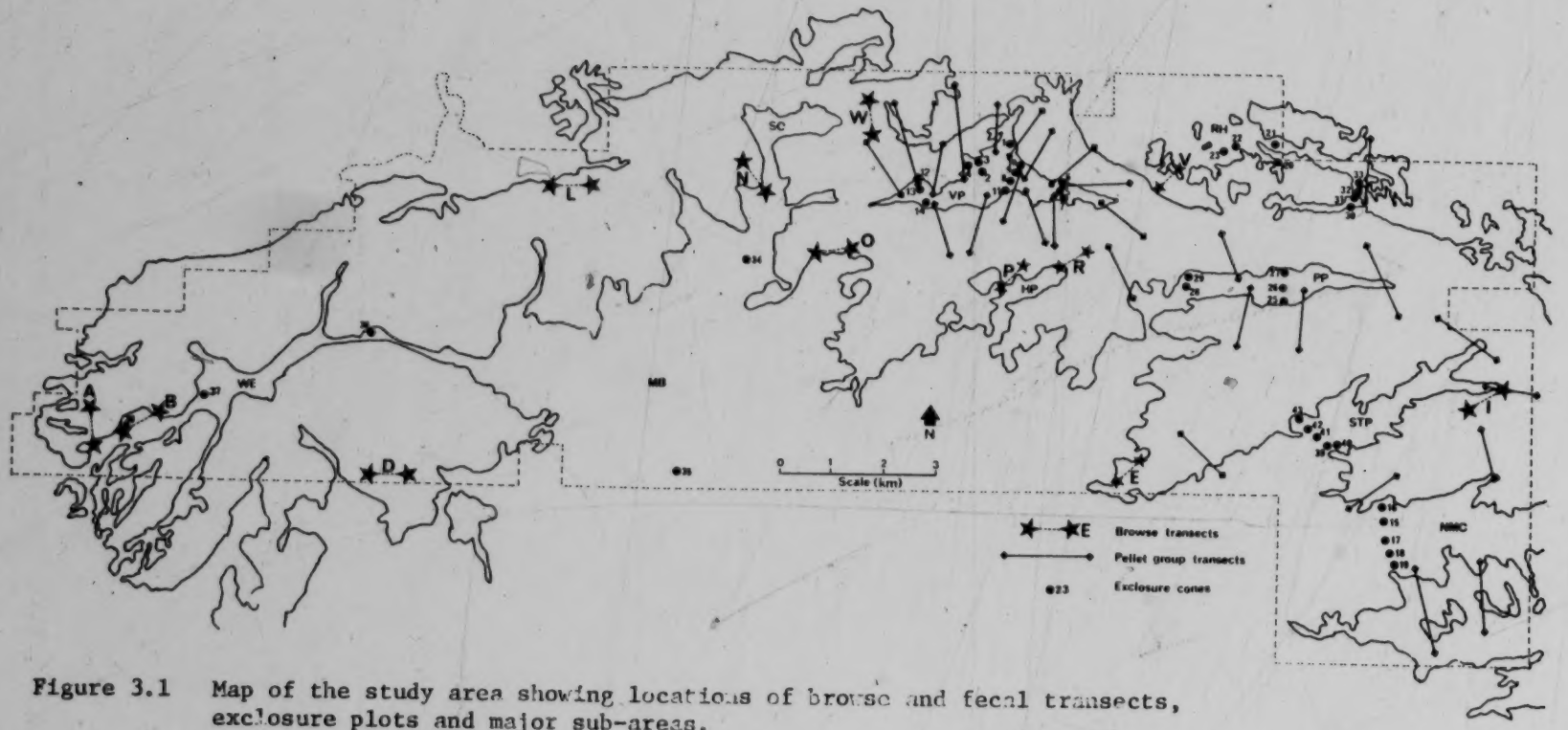

Figure 3.1 Map of the study area showing locations of browse and fecal transects, exclosure plots and major sub-areas.

length (2.18 m). Although a pellet grouping (for elk) usually consists of a minimum of 30 pellets (Smith 1964), 5 pellets were considered a grouping in this study (since the intent was not to determine absolute numbers of animals but only relative distributions). In 1978, 4 additional plots were censused for every one that was visited in 1977. These four were located around the original plot and all 5 were within a 15 m diameter circle. Therefore, in 1977, 912 plots were examined and in 1978 this increased to 4,560. These two changes greatly increased the numbers of fecal groupings counted and enhanced the predictability of the subsequent models used to analyze the data.

These transects and plots were visited twice per year in 1977 and 1978 - once in June to determine winter and spring use[3] and once in August to determine summer use. To prevent recounting on subsequent surveys, feces initially noted were either removed from the plot or marked with flourescent paint (Rufield 1968). Information on fall preferences was obtained during the 1978 June census of the Viewpoint Plateau transects because all elk had apparently left this area by December, 1977.[4] Therefore all pellets located had to have been dropped between August 30 and December 1, 1977.

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[3] The distinction was based on the amorphous nature of spring droppings.
[4] This was based on local staff reports.

Environmental descriptions were recorded in conjunction with fecal information and included both abiotic and biotic parameters (Appendix E).

3.23 Habitat Utilization - Regional Preferences and Annual Changes

Spring/summer regional preferences and annual changes were determined by systematic drive count observations of most open areas of the park from May 5 to August 30, 1978 and for a few selected periods in 1977. All observations were conducted during a three hour period at sunrise and sunset (Mackie 1970). During every two week period, all areas were visited five times of which two were in the early morning.

Information on regional preferences and annual changes was also obtained by comparing the transect/plot data between the Viewpoint Plateau (intensively studied) and the rest of the study area (extensively studied) in 1977 and in 1978 for both the spring/summer and the fall/ winter periods.

Since cattle are not in the study area in fall/winter, general trends in regional preferences during fall/winter were determined only for elk. Earlier reports and past aerial surveys were reviewed. More specific information was obtained in the 1977/78 winter by relating snow measurements to elk distribution trends. Two areas were chosen for the

snow measurements and these measurements were taken on February 4 to March 5, 1978 - one on the Viewpoint Plateau where there were no reported elk in that winter and the other in the Reesor Hills where a great majority of the elk spent the winter. Both snow depth and crusting measurements were taken. Basic spatial preferences were determined by pellet group transects, located in the general area which had been consistently and heavily utilized by wintering elk. These transects were censused from May 20 to June 10, 1978. All winter pellet groups found within 1.5 m on either side of the observer as he walked along belt line transects were recorded. Distance from a known starting point also was recorded and a distinction was made between recent pellet groupings (those deposited 1977/78) and old pellet groupings (i.e. those deposited in previous winters). This distinction was based largely on decomposition differences reflected in colour and flaking.

The data from these transects were examined in conjunction with topographic and vegetative physiognomic characteristics (obtained from topographic maps and air photos) in the general area in order to delineate: (a) an elk winter range for the 1977/78 winter. The southern boundary of the range used by elk was determined by restrictive snow depths. The eastern and western boundaries were determined by topographic constraints, roadways and other human disturbance. The northern boundary was

determined by subjecting the pellet grouping data (on those north-south oriented transects outside the park boundary) to linear regression. That point at which the number of elk pellets equals zero is the northern distance that elk moved from the park boundary (Appendix A); (b) areas within this overall range which contained different densities of pellet groupings.

3.24 Effects of Human Disturbance on Elk Habitat Selection

During systematic drive-counts it was apparent early in the study that:

(a) fewer elk were sighted on weekends (Saturdays and Sundays) versus weekdays. There was also an inverse relation to the amount of tourist traffic.

(b) when elk were disturbed on open grassland bench areas and they ran to seek cover, they most often exited from the bench via numerous small coulees.

The extent to which traffic affected elk presence on the open grassland bench areas was examined on the north side of the Viewpoint Plateau (see Fig. 3.1 for location). This area was chosen because cattle were for the most part, absent and because this bench had a major paved road running through it.

Fourteen coulees were chosen at various distances from the road (Fig. 3.26) and a 2 m length of fine sand was

deposited in the bottom of each coulee (often on a well-worn trail). The sand was smoothed over and revisited every 24 hours for one week each in July of 1977 and 1978. On each visit, the numbers of elk tracks were counted and the sand resmoothed. The numbers of tracks counted on weekdays at various distances from the road were compared to the number counted on weekends.

3.25 Data Analysis

Environmental descriptors recorded in conjunction with examination of transect plots for cattle and elk fecal groupings provided 912 records of independent variables describing total late spring, summer and early fall use by cattle and spring, summer (1977 and 1978), fall (1977) and fall/winter (1976-77) use by elk. Since the small size of the plots reduced biases in terms of locating fecal piles (Neff 1968, Smith 1964) and since the frequency of their re-examination (in June and August of 1977 and 1978) reduced biases in terms of differential rates of decay, abundance data was used for many calculations.

To the extent that fecal groups are reliable indicators of spatial distribution, abundances of elk and cattle fecal groupings on transect plots were used as measures of spatial and habitat occupancy by these ungulates. Space and habitat resources were differentiated on the basis of land unit size: habitat refers to gross cover types or vegetation

associations while spatial resource refers to transect plots within these larger units. This differentiation is made because ungulate selectivity may differ substantially from a macro to micro scale (Anthony and Smith 1977). Degree of specialization (Hurlbert's "patchiness", equation 23), intraspecific crowding (Hurlbert's equation 20) and distributional uniformity (Hurlbert's equation 28) (the formulae used are those of Lloyd 1967, as modified by Hurlbert 1978) were used to evaluate spatial characteristics of each ungulate. Degree of selectivity, or specialization, indicates the probability of intraspecific encounter or the probability of two individuals of the same species attempting to utilize the same space (plot) over the length of the study. Values range from 1.00 (or 0%) or greater. Intraspecific crowding is the mean density of individuals (fecal piles) of the same species confronting an individual and values range from 0 to greater than 0. Distributional uniformity values range from 0 to 1.0 - a value of 1.0 indicates a perfectly uniform distribution, the lower the value, the more clumped the distribution (formulae are in Appendix D). The indices of spatial characteristics should be treated as single measurements rather than as estimates of population parameters, for little is known about the statistical distribution of these measurements and plot size would vary their values. However, since plot size and numbers were consistent for all species, the values should

be comparatively accurate among species. All indices were evaluated on fecal groupings found in all 5 microplots

Occurrences of fecal groups were tabulated on the basis of canopy cover types and vegetation association types. Expected distributions were calculated on the basis of availability of each type, and compared to observed distribution using chi-square: $X^2 = (O - E)^2/E$ where O = number of fecal piles in habitat type, E = number of plots sampled in habitat type / total number of plots sampled x total number of fecal piles. Significant differences in use of habitat types were assumed to indicate highly favoured or avoided. The strength of preference or avoidance was determined by an affinity index which was calculated by the percent of fecal piles in that type divided by the percent of transect plots in that type. An index of 1.0 suggests utilization equal to availability, larger numbers imply preference for and smaller ones avoidance of the particular type.

Response to environmental variables was first evaluated by chi-square. Because the number of categories of each independent variable was small (<9) it was possible to calculate confidence intervals on each category (Neu et al. 1974) and thus determine the statistical significance of preference or avoidance. Distribution of fecal groups was also evaluated within the context of a multivariate model using Multiple Classification Analysis (MCA) (Andrews et al.

1967). The restriction of non-interaction of the independent variables necessitated reduction of the number of independent variables, resulting in utilization of preliminary THAID analyses (Morgan and Messenger 1973) using abundance data as dependent variables. THAID outputs "a subset of predictors and possible interactions (non-additivities) which provide an explanatory model for the particular variable chosen" (University of Michigan 1973). Based on the THAID analysis, reduced sets of predictor variables were chosen for input into MCA. Individual MCA runs were conducted using total cattle fecal groups and fall/winter, spring/summer, spring, summer, fall and cumulative seasonal elk pellet groups, all based on abundance data. The eta^2 statistic is the one-way analysis of variance coefficient indicating the bivariate relationship (explained variance) between the dependent variable and each predictor variable. The beta^2 statistic is an experimental statistic indicating the predictive power (explained variance of each independent variable while controlling for all others). MCA is a technique for examining the interrelationships between several predictor variables and a dependent variable. The statistics printed by the program show how each predictor relates to the dependent variable, both before and after adjusting for the effects of others predictors and how all the predictors considered together relate to the dependent variable.

3.3 Patterns of Cattle Habitat Utilization

3.31 General Patterns

Cattle made at least some use of all gross vegetation associations and all canopy cover types. Fecal groups representing the May to October grazing season deposition occurred on 36% of the fecal group plots. The probability of intraspecific encounter or the probability of two individual cows attempting to utilize the same plot over the length of the study was 289% higher than it would have been if cattle were the perfect generalist (degree of selectivity, Table 3.1). On the average a cow would have found itself with 4.08 other cows in any one plot it was in.

Sign occurred more frequently than expected in four canopy cover types - all with no or very light tree cover. These four cover types occurred in 35% of the total number of plots examined but contained 69% of the total fecal piles with the grasslands areas containing 54% of all the fecal piles (Table 3.2). Sign occurred on considerably fewer plots than expected in 4 canopy cover types which were, in decreasing order of avoidance, mixed forest, closed canopy conifer, dense pine and deciduous forest. Frequency of occurrence of sign within the coniferous forest type was about the same as expected from their distribution within the study area.

Table 3.1 Spatial distribution characteristics of elk and cattle. (See Appendix D for equations).

Species and Season	Degree of Selectivity	Intraspecific Crowding	Distributional Uniformity
Total Cattle[4]	3.89[1]	4.08[2]	.21[3]
Total Elk[4]	2.15	3.49	.36
Fall-Winter Elk[5]	2.78	1.79	.23
Spring-Summer Elk[4]	2.39	1.61	.26
Spring Elk[4]	2.41	.65	.16
Summer Elk[4]	2.66	1.12	.20
Fall Elk[6]	7.67	2.95	.03

1 The probability of 2 individuals utilizing the same site over the length of the study is 289% (389 - 100%) higher than it would be if cattle were the perfect generalist.

2 An individual would have found that there had been 4.08 other individuals in that same site over the length of the study.

3 If cattle were distributed uniformly they would have a value of 1.0; the lower the value the more clumped the distribution.

4 Combined 2 years data.

5 Fall-winter of 1976-77.

6 Fall of 1977.

Table 3.2 Distribution of fecal groups of cattle by canopy cover type. (see Appendix A for locations of cover types).

Canopy Cover Type	% of Sampled plots in Cover type (n=912)	% of Fecal Groups in plots within various Canopy cover type (n=952)[1]	Affinity Index
1. Grassland, 1/3 of area in tree cover	26.0	54.4	2.1+[2,3]
2. 30-50% deciduous or coniferous cover	1.9	4.2	2.2+
3. 50-75% deciduous or coniferous cover	0.8	2.1	2.6+
4. Fairly continuous cover with frequent openings	6.6	8.4	1.3+
5. Deciduous forest with or without scattered conifer	12.0	8.2	.7-
6. Mixed forest	21.3	4.1	.2-
7. Coniferous forest with or without scattered deciduous	12.2	12.3	1.0
8. Closed canopy conifer	12.8	3.2	.3-
9. Dense pine - old burn	6.4	3.2	.5-
Total %	100	100.1	

1 Combined 1977-78.

2 An index of 1.0 suggests utilization equal to availability, larger numbers imply preference for and smaller ones avoidance of the particular cover type.

3 Chi-square tests were performed on the data set on the null hypothesis that observed distribution = expected distribution (p .05) (+ = fecal groupings occur more frequently than expected; - = fecal groupings occur less frequently than expected; no sign = fecal groupings occur as frequently as expected or category too small for calculation of confidence limits).

These distribution patterns are defined further by considering the vegetation associations (Table 3.3). The five preferred association types occupied 30.3% of the total area and contained 64% of the total fecal piles, with two areas - grassland bench and shrubland occupying 21% of the total area and containing 47% of the total fecal piles. Not all open areas were preferred, as was implied by the canopy cover types, but grassland non-bench areas received utilization equal to availability. But there were no open areas that were avoided. None of the forested types were preferred, with the exception of parkland types, which were immediately adjacent to the open grassland areas. Wetland areas containing a spruce canopy also were preferred; these areas commonly occurred in valley bottoms which had small streams.

Chi-square tests were performed on the data to test preference or avoidance of various environmental features. Sign occurred more frequently than expected on plots with no tree cover, whether coniferous or deciduous; with no shrub cover, or if there was shrub cover, there was a preference for those plots containing rose (Rosa spp.) and/or spruce (Picea glauca) of shrub size; for fairly heavy grass cover of almost any species; for a relatively light to medium amount of grassland duff; for plots containing any amount of shrubby cinquefoil (Potentilla fruticosa) cover; for no forest deadfall; for grassland areas at any distance from

Table 3. 3 Distribution of fecal groupings of cattle by vegetation associations (partly after Newsome and Dix, 1968).

Vegetation Association	% of Sampled plots in cover type (n=912)	% of Fecal Groups in plots within various associations (n=952)[1]	Affinity Index
Parklands			
Pine	0.5	.5	.9
Pine Aspen	1.5	5.3	3.5+[2,3]
Aspen	4.1	5.5	1.3+
Slopes			
Pine	15.4	7.0	.5-
Pine Aspen	8.7	5.5	.6-
Aspen Pine	6.0	5.8	1.0
Aspen	6.6	2.6	.4-
Aspen Spruce	7.3	1.3	.2-
Spruce Aspen	9.7	3.8	.4-
Pine Spruce	5.0	1.9	.4-
Spruce Pine	2.8	.1	0.0-
Wetlands			
Spruce	4.1	5.8	1.4+
Poplar	0.1	.2	1.9
Open Areas			
Grassland Bench	15.4	40.1	2.6+
Grassland non-bench	7.3	7.3	1.0
Shrubland	5.2	7.1	1.4+
Total %	100	99.8	

1 Combined 1977-78.

2 An index of 1.0 suggests utilization equal to availability, larger numbers imply preference for and smaller ones avoidance of the particular cover type.

3 Chi-square tests were performed on the data set on the null hypothesis that observed distribution = expected distribution (p .05) (+ = fecal groupings occur more frequently than expected; - = fecal groupings occur less frequently than expected; no sign = fecal groupings occur as frequently as expected or category too small for calculation of confidence limits.

cover; and for very slight to no slope. Under-utilized environmental features were any amount of tree cover, but particularly coniferous cover; very heavy shrub cover and espeially light grass cover or extremely heavy grass cover especially dcminated by Calamagrostis spp.; heavy amcunts of grassland duff; almost any amount of forest deadfall; more than 21 metres from grassland habitats; slopes over 10° and north facirg slopes (Table 3.4).

A reduced set of environmental features accounted for 44% of the variation in fecal group numbers found on the plots (generalized R^2 Table 3.4). Of the 14 variables, 9 accounted individually for more than 12% of this variation (eta^2 values, Table 3.4); these were, in descending crder, amcunt of grassland duff, aspect, amount cf Potentilla fruticosa cover, first major (dominant) shrub species, amcunt of forest deadfall, first and seccnd majcr grass species, tree cover and distance to grassland habitats. Neither amount of shrut ccver, the second major shrub species, amcunt of grass cover, density of fcrest understory or slope explained much of the variation.

The relative importance of the 9 most important variables, when all other variables were "held ccnstant" were, in descending order, first major grass species, forest deadfall, amcunt of grassland duff, cover cf Potentilla fruticosa, tree cover, second major grass species, distance to grassland, shrub cover and slope. There were strong

Table 3.4 Total Response of cattle to individual features of habitat.

Multiple Relationships: Generalized R^2 = ; Multiple R = ; Multiple R^2 =

	Direction of Response	eta	beta	MCA Coefficient
Conifer Cover				
None	+			
1 - 5%	0			
6 -25	-			
26 -50	-			
51 -75	-			
76+	-			
Deciduous Cover				
None	+			
1 - 5%	-			
6 -25	-			
26 -50	0			
51 -75	0			
76 -100	0			
Tree Cover		0.128	0.112	
None	+			
1 -10%	-			-1.145
11 -25	-			0.407
26 -50	-			0.436
50+	-			0.480
				0.196
1st Major Tree				
None	+			
Populus trem.	-			
P. balsam.	0			
Picea glauca	-			
Pinus contorta	-			
2nd Major Tree				
None	+			
Populus trem.	-			
P. balsam.	0			
Picea glauca	-			
Pinus contorta	0			
Shrub Cover		0.023	0.029	
None	+			
1 - 5%	0			0.800
6 -25	0			0.142
26 -50	0			0.114
51 -75	-			-0.056
76+	-			-0.614
				-0.877

	Direction of Response	eta	beta	MCA Coefficient
1st Major Shrub		0.133	0.020	
None	0			-0.205
Rosa spp.	+			0.061
Symphoricarpos spp.	0			0.120
Shepherdia canad.	-			0.326
Eleagnus com.	0			-1.786
Amelanchier alni.	-			-0.079
Potentilla fru	-			-0.464
Picea glauca	+			0.506
Other	-			-0.158
2nd Major Shrub		0.027	0.013	
None	+			-0.441
Rosa spp.	+			-0.055
Symphoricarpos spp.	0			0.202
Shepherdia canad.	-			-0.211
Eleagnus com.	0			-1.180
Amelanchier alni.	0			0.261
Potentilla fru	-			0.227
Picea glauca	+			-0.457
Other	0			0.098
Herb Cover				
None	0			
1 - 5%	0			
6 -25	0			
26 -50	0			
51 -75	0			
76+	0			
Grass Cover		0.091	0.017	
None	0			
1 - 5%	-			0.477
6 -25	-			0.352
26 -50	+			-0.004
51 -75	+			0.006
76+	-			-0.167
				-1.444

Table 3.4 continued.

	Direction of Response	eta	beta	MCA Coefficient
1st Major Grass		0.129	1.156	
None	0			-0.086
Calamagrostis spp.	-			1.360
Agropyron spp.	+			-3.612
Danthonia spp.	+			-3.915
Festuca spp.	0			-4.620
Koeleria crist.	+			-3.916
Stipa spp.	+			-3.519
Other	+			-0.908
2nd Major Grass		0.129	0.064	
None	0			-0.586
Calamagrostis spp.	-			-0.261
Agropyron spp.	0			-0.339
Danthonia spp.	+			0.737
Festuca spp.	+			0.102
Koeleria crist.	+			0.834
Stipa spp.	+			1.184
Other	+			1.371
Density of Forest Under		0.120	0.004	
0%	0			-0.813
1 -20	-			-0.198
21 -40	-			-0.229
41 -60	-			0.118
61 -80	-			-0.037
81+	-			0.119
Not in forest	+			
Amount of Grassland Duff		0.220	0.244	
0%	+			1.964
1 -20	+			1.725
21 -40	+			2.944
41 -60	0			0.008
61 -80	-			-0.504
81 -100	0			-2.457
Not on grassland	-			
Potentilla fru Cover		0.150	0.130	
0 per 45 m^2				1.071
1 - 5				1.024
6 -10				1.493
11 -20				2.072
21 -30				1.392
30+				0.041
Not on grassland				

	Direction of Response	eta	beta	MCA Coefficient
Forest Deadfall		0.131	0.259	
0%	+			-0.302
1 -20	-			-0.541
21 -40	-			-0.607
41 -60	-			-0.977
61 -80	-			-1.091
81+	0			1.771
Not in forest	+			
Distance to Grassland		0.126	0.033	
0 metres	+			0.098
1 -20	0			-0.159
21 -50	-			-0.395
51 -100	-			-0.496
101 -200	-			-0.146
200+	-			0.601
Distance to Cover				
0 metres	-			
1 -20	+			
21 -50	+			
51 -100	+			
101 -200	+			
200+	0			
Slope		0.071	0.023	
0 -10°	+			0.234
11 -20	-			-0.127
21 -30	-			-0.159
30+	-			-0.765
Aspect		0.165	0.119	
No slope	+			1.475
N	-			-0.591
S	0			0.059
E	0			-0.064
W	0			-0.450

Based on X^2 tests with the hypothesis that occurrance of fecal groups follow expected patterns ($p \leq .05$). (+ = sign occurs more frequently than expected; 0 = sign occurs as frequently as expected, or category too small for calculation of confidence intervals; - = sign occurs less frequently than expected).

positive associations with a medium amount of tree cover, none to light amount of shrub cover of Shepherdia canadensis, Symphoricarpos albus, Amelanchier alnifolia, no grass cover, or grass cover of Calamagrostis spp., a medium or heavy amount of forest understory, a light amount of grassland duff, a medium amount of Potentilla fruticosa, either on the grassland or more than 200 m away, a slight or no slope and a south facing aspect. There were strong negative associations with an absence of tree cover, heavy shrub cover, all grass species except Calamagrostis spp., except when Stipa spp., Koeleria cristata or Festuca spp. were the second major grass species, light amounts of forest understory, heavy grassland duff, almost any amount of deadfall, 21-100 m from grassland communities, slopes over 10° and north and west facing slopes. There appeared to be a dichotomous preference for features associated both with grassland and forest habitats.

3.32 Annual and Regional Patterns

Cattle animal unit months[5] differed on an annual basis but have probably been within the 10,000 to 17,000 range since at least 1920 (Section 2.7). It is only since 1977 that accurate records of numbers of cattle within the park were kept.

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[5]One animal unit month (AUM) consumes 454 kg of forage per month and is equivalent to one cow with calf (Heady 1975).

In 1977 there were 15,256 AUM's and in 1978 there were 10,431 AUM's in the park (Fig. 3.2). This implies that dramatic changes in numbers occurred on an annual basis. These cattle were distributed mainly within three stock Associations, Medicine Lodge Stock Association, Battle Creek Stock Asscciation and Fox Stock Associaticn (locations are on Fig. 3.3). These three stock associations had allotments of 14,485 AUM's distributed over 88% of the entire park. In additicn, there are about 595 AUM's allotted to various individuals over 3% of the park area. Figures 3.4 and 3.5 show the 1977 and 1978 stocking rates within the three associations.

Although all associations had a decline in AUM's from 1977 to 1978, Battle Creek Stock Associaticn had the greatest decrease - 1978 numbers were only 57% of the 1977 numbers while the other two associations had over 73% of the 1977 values. As well as lower numbers in 1978, there was also a reduced length of grazing season. In 1977, the first two weeks of May received 45 AUM's of use in the Medicine Lodge Stock asscciation, while in 1978 there was no use. In 1977, the first two weeks of October received 749 AUM's in the Battle Creek Stock Association and 443 AUM's in the Fox Stock Asscciation but in 1978 the values were 0 and 96, respectively. There was a consistent temporary decrease in cattle numbers in the park in mid July, when many cattle were removed for breeding purposes (Figs. 3.2, 3.4, 3.5).

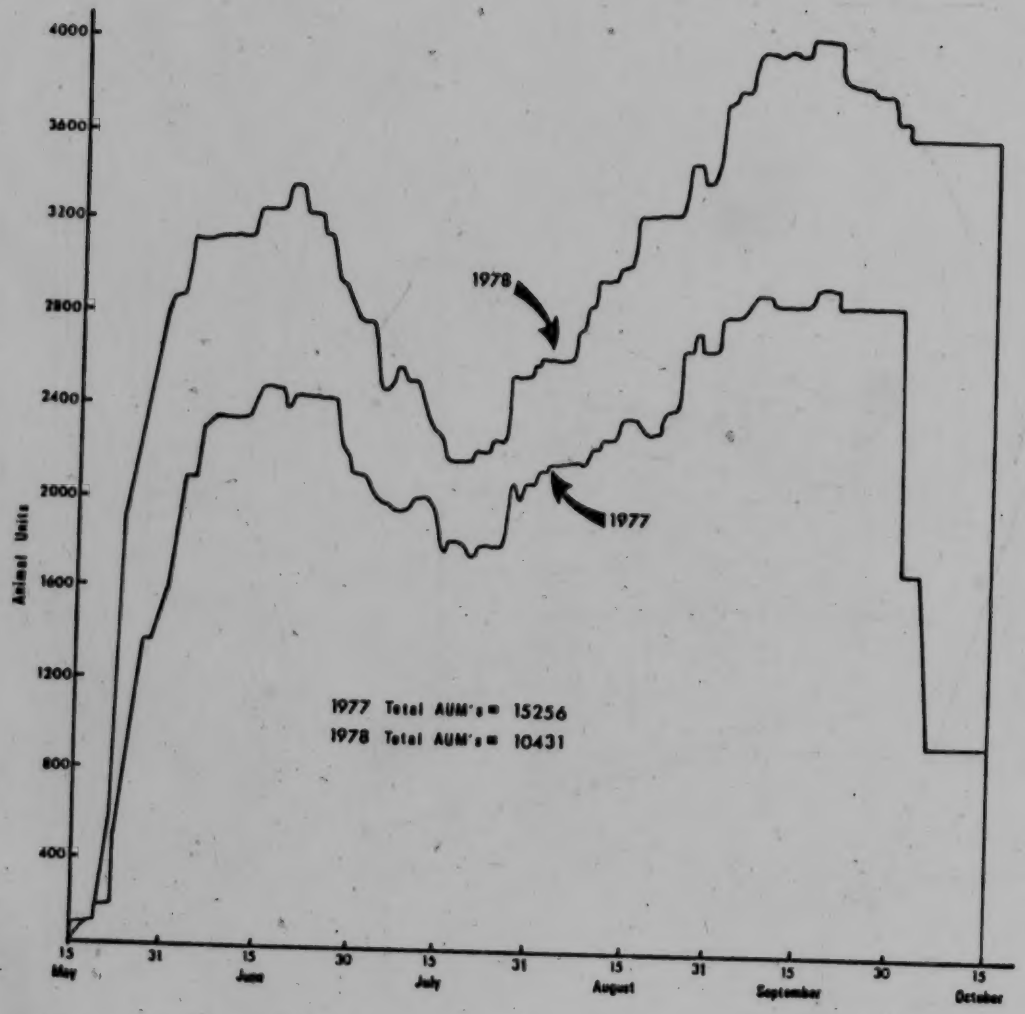

Figure 3.2 Cattle animal unit months in the study area in 1977 and 1978.

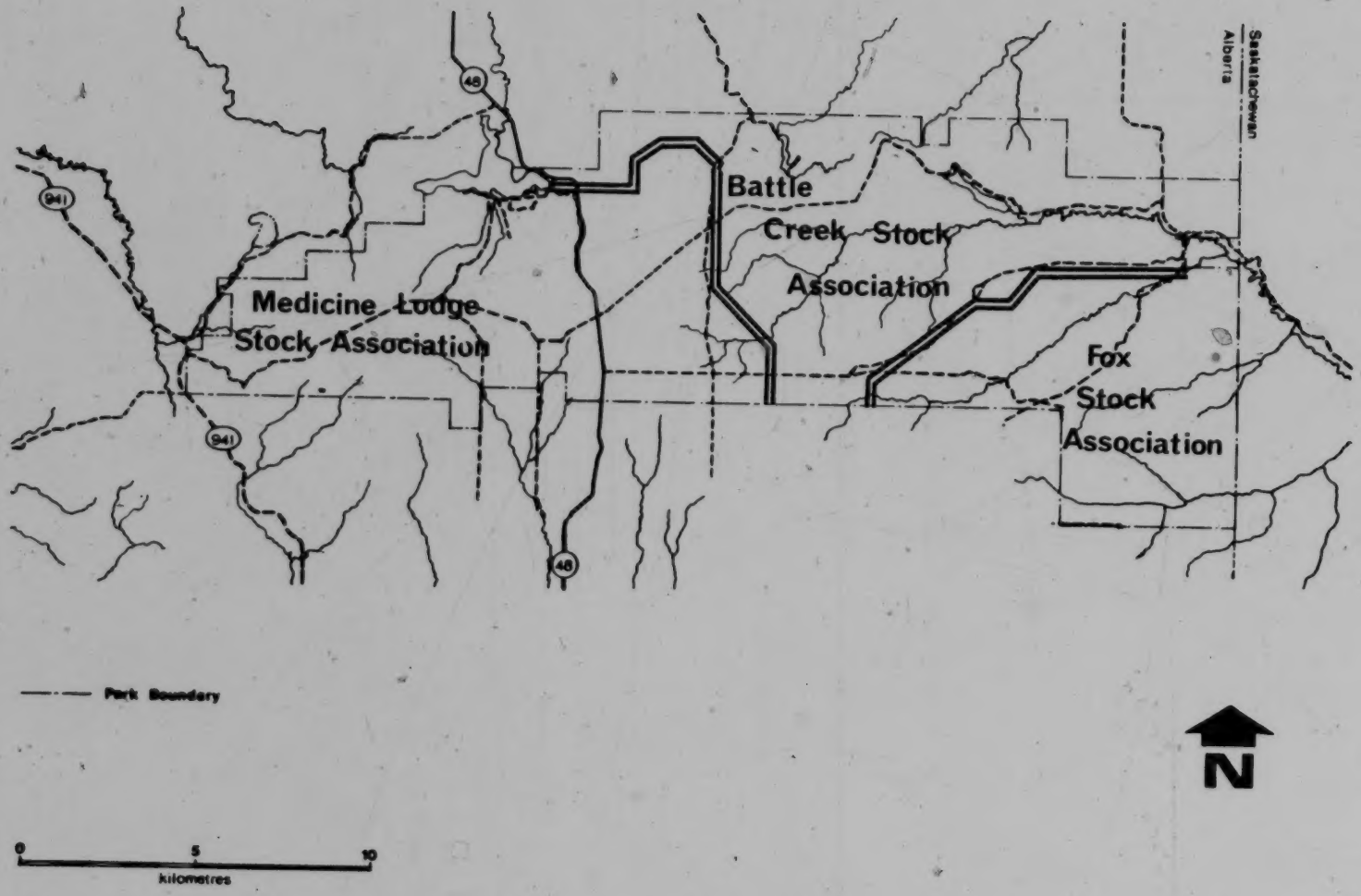

Figure 3.3 Map of the study area showing locations of the three major stock associations.

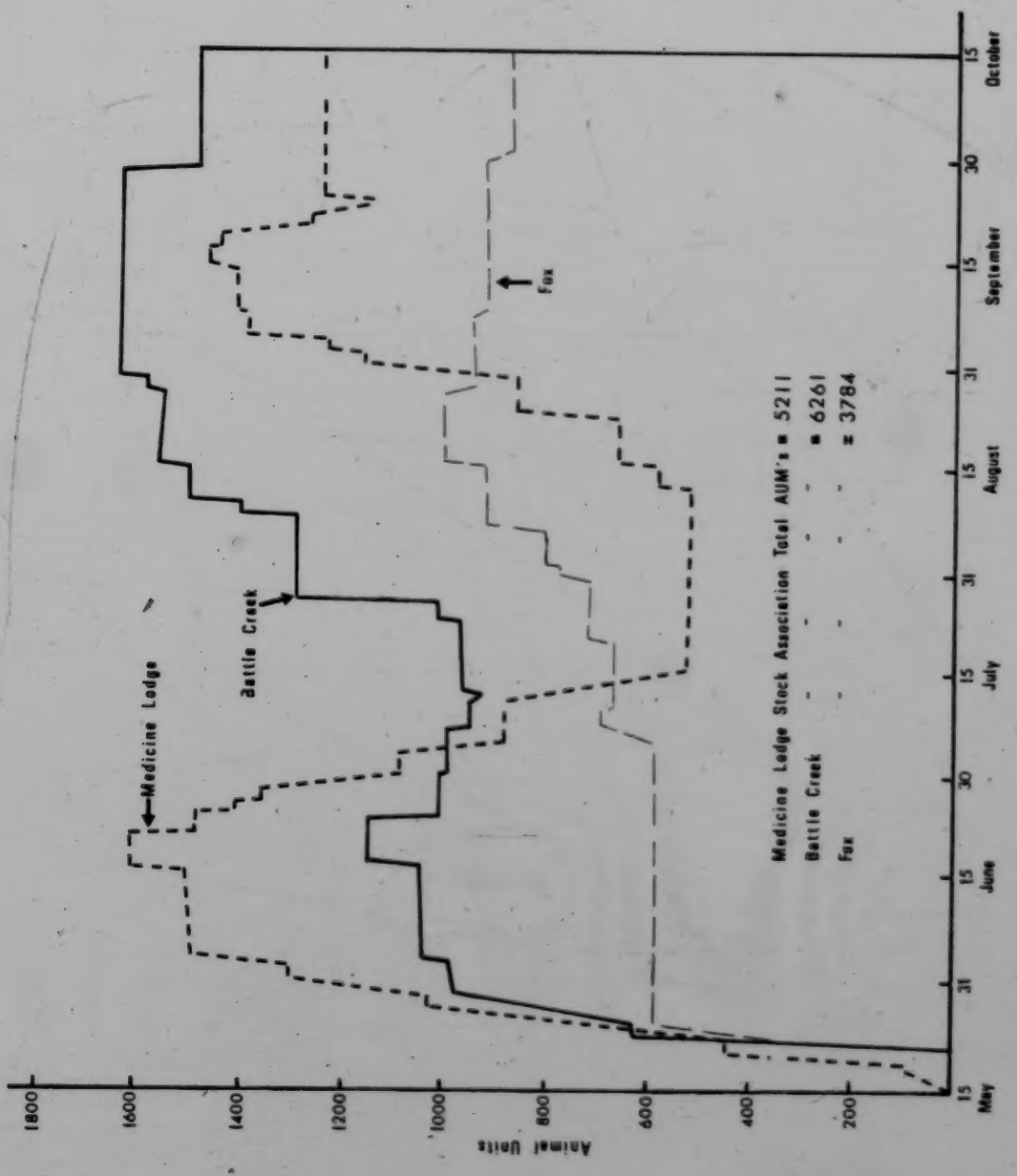

Figure 3.4. 1977 cattle AUM's in the study area within the three major stock associations.

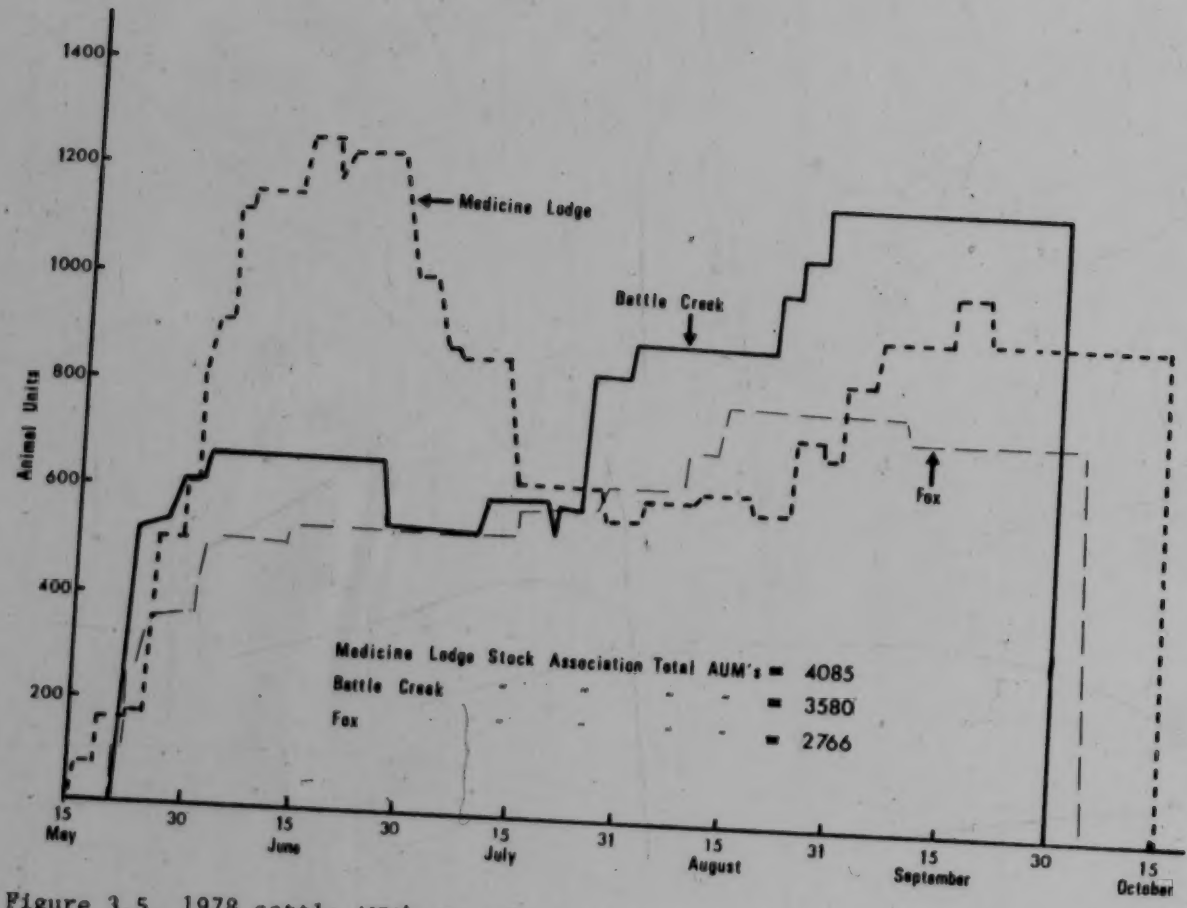

Figure 3.5. 1978 cattle AUM's in the study area within the three major stock associations.

Annual direction of response to various canopy cover types changed very little from 1977 to 1978 (Table 3.5). There was only one opposing response from one year to the next in all 9 types. The coniferous forest with or without scattered deciduous type was avoided more often than expected 1977 and was preferred more often than expected in 1978. Of the various vegetation associations, shrublands were preferred more than expected in 1977 and avoided more than expected in 1978. Regional changes in preferences were very minimal, at least in the region being considered in Table 3.6.

3.4 Patterns of Elk Habitat Utilization

Cumulative (multi-season) distribution of elk provides a generalized background of environmental preferences against which seasonal patterns can be considered. Four seasonal units were delimited as: spring (April - May), summer (June - August), fall 1977 (September - November) and winter 1976-77 (December - March). These units are somewhat arbitrary and although somewhat relatable to certain phenological events (spring - beginning of green-up and disappearance of snow; summer - cattle in park and heavy tourist traffic; fall - cattle removed, great reduction in tourist traffic and breeding season of elk; winter - no cattle, maximum snow cover and minimum forage availability), these events may change annually and sometimes profoundly

Table 3. 5 Direction of response: annual and regional preferences of cattle by various canopy cover types.

Canopy Cover Type	Overall Direction of Response (2 years and all areas)[3]	Annual Direction of Response 1977	Annual Direction of Response 1978	Regional Direction of Response[1]
1. Grassland, 1/3 of area in tree cover	+(2.1)[2]	+(2.5)	+(1.7)	+(1.7)
2. 30-50% deciduous or coniferous cover	+(2.2)	+(3.0)	0(1.3)	0(0)
3. 50-75% deciduous or coniferous cover	+(2.6)	0(2.0)	+(3.0)	+(2.5)
4. Fairly continuous cover with frequent openings	+(1.3)	0(0.7)	+(1.8)	+(1.3)
5. Deciduous forest with or without scattered conifer	-(0.7)	-(0.6)	-(0.7)	-(0.5)
6. Mixed forest	-(0.2)	-(0.2)	-(0.3)	-(0.2)
7. Coniferous forest with or without scattered deciduous	0(1.0)	-(0.5)	+(1.5)	+(1.9)
8. Closed canopy conifer	-(0.3)	-(0.2)	-(0.3)	-(0.2)
9. Dense pine - old burn	-(0.5)	-(0.6)	-(0.3)	0(0)

1 This is based on transects 1-17, all of which were located on or adjacent to the Viewpoint Plateau (see Fig. 3.1 for locations).

2 Based on chi-square tests of the various data sets on the null hypothesis that observed distribution = expected distribution (p .05) (+ = fecal groupings occur more frequently than expected; - = fecal groupings occur less frequently than expected; 0 = fecal groupings occur as frequently as expected or category too small for calculation of confidence limits.

3 Taken from Table 3.3. (Affinity Index).

Table 3.6 Direction of response: annual and regional preferences of cattle for various vegetation associations.

Vegetation Association	Overall Direction of Response (2 years and all areas)[2]	Annual Direction of Response 1977	Annual Direction of Response 1978	Regional Direction of Response[3]
Parklands				
Pine	0[1](0.9)	0(1.0)	0(0.8)	0(0.9)
Pine Aspen	+(3.5)	+(1.9)	+(5.0)	+(4.0)
Aspen	+(1.3)	0(0.8)	+(1.8)	+(1.7)
Slopes				
Pine	-(0.5)	-(0.4)	-(0.5)	-(0.5)
Pine Aspen	-(0.6)	-(0.4)	0(0.8)	0(0.8)
Aspen Pine	0(1.0)	-(0.6)	0(1.3)	0(0.9)
Aspen	-(0.4)	-(0.4)	-(0.3)	-(0.1)
Aspen Spruce	-(0.2)	-(0.2)	-(0.1)	-(0.1)
Spruce Aspen	-(0.4)	-(0.3)	-(0.3)	-(0.4)
Pine Spruce	-(0.4)	-(0.4)	-(0.4)	-(0.3)
Spruce Pine	-(0.0)	0(0.0)	-(0.1)	-(0.0)
Wetlands				
Spruce	+(1.4)	0(1.2)	+(1.7)	+(1.5)
Poplar	0(1.9)	0(0.0)	0(0.0)	0(1.8)
Open Areas				
Grassland Bench	+(2.6)	+(3.0)	+(2.5)	+(2.1)
Grassland non-bench	0(1.0)	0(1.3)	-(0.6)	0(0.8)
Shrubland	+(1.4)	+(2.2)	-(0.3)	0(1.1)

1 Based on chi-square tests of the various data sets on the null hypothesis that observed distribution = expected distribution ($p < .05$) (+ = fecal groupings occur more frequently than expected; - = fecal groupings occur less frequently than expected; 0 = fecal groupings occur as frequently as expected or category too small for calculation of confidence limits.

2 Taken from Table 3.3 (Affinity Index).

3 This is based on transects 1-17, all of which were located on or adjacent to the Viewpoint Plateau (see Fig. 3.1 for locations).

so.

3.41 Cumulative seasonal Use

Elk made at least some use of all gross vegetation associations and all canopy cover types. Pellets groups representing all seasons-deposition occurred on 58% of the pellet group plots.

The probability of intraspecific encounter or the probability of two elk individuals attempting to utilize the same plot over the length of the study was 115% higher (215-100%) than it would have been if elk were the perfect generalist (degree of selectivity, Table 3.1). On average, an elk would have found that there had been 3.49 other elk in any one plot it was located in, over the length of the study.

Sign occurred more frequently than expected in two canopy coverage types - the grassland areas and coniferous forest with or without scattered deciduous trees. These two cover types occupied 38% of the total area but contained 56% of all elk pellets (Table 3.7).

Sign occurred on considerably fewer plots than expected in 5 canopy cover types with the mixed forest, deciduous forest, continuous cover with frequent openings and dense pine - old burn types being more important (as they respectively occupied the greatest aerial extent). Frequency of occurrence of sign within the closed canopy conifer type

Table 3.7. Seasonal distribution of elk pellet groups by canopy cover type (See Appendix A for locations).

Canopy Cover Type	% of Sampled plots in habitat type (n=912)	% of Fecal groups in plots within various canopy cover type						Affinity Index[1]					
		Total[3] (n=1460)	Fall Winter[2] (n=587)	Spring Summer[3] (n=616)	Spring[3] (n=241)	Summer[3] (n=388)	Fall[4] (n=350)	Total	Fall Winter	Spring Summer	Spring	Summer	Fall
1. Grassland, <1/3 of area in tree cover	26.0	36.4	47.0	24.5	27.0	20.6	44.6	1.4+[5]	1.8+	.9	1.0	.8-	1.7+
2. 30-50% deciduous or coniferous cover	1.9	1.3	0.7	1.8	1.7	.3	1.7	.7	.4-	.9	.9	.2-	.9
3. 50-75% deciduous or coniferous cover	0.8	0.3	.2	.3	.8	0	.3	.4-	.3	.4	1.0	0	.4
4. Fairly continuous cover with frequent openings	6.6	4.9	4.0	7.0	8.7	5.4	1.4	.7-	.6-	1.1	1.3	.8	.2-
5. Deciduous forest with or without scattered conifer	12.0	7.7	6.1	11.0	10.8	13.7	4.6	.6-	.5-	.9	.9	1.1	.4-
6. Mixed forest	21.3	12.7	8.9	17.7	14.1	21.6	7.7	.6-	.4-	.8	.7-	1.0	.4-
7. Coniferous forest with or without scattered deciduous	12.2	20.1	18.4	20.3	20.3	20.1	23.4	1.6+	1.5+	1.7+	1.7+	1.6+	1.9+
8. Closed canopy conifer	12.8	12.3	10.2	12.2	9.5	12.9	15.1	1.0	.8	1.0	.7	1.0	1.2
9. Dense pine - old burn	6.4	4.2	4.4	5.2	7.1	5.4	1.1	.7-	.7	.8	1.1	.8	.2-
TOTAL %	100	99.9	100	100	100	100	99.9						

1 An index of 1.0 suggests utilization equal to availability, larger numbers imply preference for and smaller ones avoidance of the particular cover type.

2 Refers to a relatively mild winter (1976-77).

3 Combined 1977-78.

4 Fall of 1977.

5 Chi-square tests were performed on each data set on the null hypothesis that observed distribution = expected distribution ($p \leq .05$) (+ = fecal groupings occur more frequently than expected; - = fecal groupings occur less frequently than expected; no sign = fecal groupings occur as frequently as expected or category too small for calculation of confidence limits.

was about the same as expected from the distribution of this type within the study area.

These distribution patterns are defined further by considering the vegetation associations (Table 3.8). The five preferred types occupied 42% of the total area and contained 66% of the total pellet groupings with three of those areas - pine, pine aspen and grassland bench - occupying 39% of the area and containing 61% of the total pellet groupings. Not all open areas were preferred as non-bench grasslands and shrublands had fewer sign than expected. As well, not all coniferous forests were preferred - those containing much spruce had less fecal groupings than expected. Again, deciduous forests were avoided unless they contained considerable amounts of pine.

Chi-square tests were performed on the data to test preference or avoidance of various environmental features. Sign occurred more frequently than expected on plots with no tree cover, or with pure pine tree cover of relatively heavy density, relatively light shrub cover of spruce, heavy grass cover dominated by Agropyron spp. or Festuca spp. with secondary grass species of Agropyron spp. or Festuca spp. or Danthonia spp. or Stipa spp., a medium density of forest understory, a light to heavy density of grassland duff, a light to medium density of Potentila fruticosa, a very light amount of forest deadfall, either on the grassland areas or between 51 and 100 from them or more than 21 m from cover

Table 3.8. Seasonal distribution of elk fecal groupings in various plant community associations (partly after Newsome & Dix, 1968).

Plant Association	% of Sampled plots in association type (n=912)	% of fecal groups (based on plot data) occurring in various vegetation associations						Affinity Index[1]					
		Total[3] (n=1460)	Fall Winter[2] (n=587)	Spring Summer[3] (n=616)	Spring[3] (n=241)	Summer[3] (n=388)	Fall[4] (n=350)	Total	Fall Winter	Spring Summer	Spring	Summer	Fall
Parklands													
Pine	.5	1.5	1.5	1.8	1.9	1.6	0.8	2.8+[5]	2.7+	3.2+	3.6+	2.9+	1.5
Pine Aspen	1.5	3.2	4.4	1.8	2.3	1.1	9.7	2.1+	2.9+	1.2	1.5	.7	6.4+
Aspen	4.1	2.9	2.3	3.4	3.5	3.2	3.5	.7-	.5-	.8	.8	.8	.9
Slopes													
Pine	15.4	19.2	15.7	20.5	19.3	17.5	18.4	1.2+	1.0	1.3+	1.3	1.1	1.2
Pine Aspen	8.7	12.6	9.2	17.1	16.2	18.5	9.7	1.4+	1.1	2.0+	1.9+	2.1+	1.1
Aspen Pine	6.0	7.1	5.2	9.6	12.4	9.3	4.9	1.2	.9	1.6+	2.1+	1.6+	.8
Aspen	6.6	3.3	2.3	5.4	2.7	5.3	.8	.5-	.3-	.8	.4-	.8	.4-
Aspen Spruce	7.3	1.9	1.6	2.6	2.7	7.9	1.1	.3-	.2-	.4-	.4-	1.1	.1-
Spruce Aspen	9.7	4.1	4.2	4.0	3.1	4.2	3.2	.4-	.4-	.4-	.3-	.8-	.3-
Pine Spruce	5.0	4.8	5.2	6.7	6.2	6.6	2.4	1.0	1.0	1.3	1.2	1.3	.5-
Spruce Pine	2.8	1.7	2.3	1.3	1.2	1.3	.8	.6-	.8	.5-	.4	.5	.3-
Wetlands													
Spruce	4.1	1.7	1.5	1.9	2.3	1.6	1.4	.4-	.4-	.5-	.6	.4-	.3-
Poplar	0.1	0	0	0	0	.3	0	0.1	0	0.1	0	2.4	0
Open Areas													
Grassland Bench	15.4	29.7	37.5	17.6	21.6	15.1	39.2	1.9+	2.4+	1.1	1.4+	1.0	2.5+
Grassland non-bench	7.3	4.2	5.2	4.2	3.1	3.4	2.4	.6-	.7-	.6-	.4-	.5-	.3-
Shrubland	5.2	2.2	2.1	2.2	1.5	3.2	1.6	.4-	.4-	.4-	.3-	.6	.3-
TOTAL %	99.7	100.1	100.2	100.1	100	100.1	99.9						

[1] An index of 1.0 suggests utilization equal to availability, larger numbers imply preference for and smaller ones avoidance of the particular association.

[2] Refers to a relatively mild winter (1976-77).

Combined 1977-78.

[3] Refers to fall of 1977.

[4] Chi-square tests were performed on each data set on the null hypothesis that observed distribution = expected distribution ($p < .05$) (+ = sign occurs more frequently than expected; - = sign occurs less frequently than expected; no sign = sign occurs as frequently as expected or category too small for calculation of confidence limits.

and a very slight or nc slope. There was a dichotomous preference fcr both certain features of grassland and treed areas. Under-utilized habitat features were light tree cover, whether it was deciduous or coniferous, very heavy deciducus cover, Populus tremuloides, Populus balsamifera or spruce cover as the major tree species or poplar and spruce as a seccndary species, heavy shrub cover, especially of Symphoricarpcs spp., Eleagnus spp., Amelanchier spp., Potentilla fruticosa, very light grass cover, Calamagrostis spp. as the first or second major grass or Kceleria cristata as the second major grass, heavy forest understory, no grassland duff or no Pctentilla fruticosa, either none or medium amcurts cf forest deadfall, areas very close to the grassland or more than 200 m away from grassland areas, steep slcpes and north and west facing aspects.

A reduced set cf individual habitat features accounted for 35% cf the variaticn in pellet group numbers found on the plots (generalized R^2, Table 3.9). Of the 14 variables, 9 accounted individually fcr 5% or more of this variation; these were, in descending order: aspect, first major shrub, grass cover, amount of grassland duff, first major grass species, second major shrub, first major tree, slope and shrub cover (eta^2 values, Table 3.9). Neither distance to grassland cr cover, second major tree species nor herb cover accounted very much for the pellet group distribution.

Table 3.9. Annual Response of elk to individual features of habitat.

Multiple Relationships: Generalized R^2 = 35 ; Multiple R = 54 ; Multiple R^2 = 29

	Direction of Response[1]	eta	beta	MCA Coefficient
Conifer Cover				
None	+			
1 - 5%	-			
6 -25	0			
26 -50	0			
51 -75	+			
76+	0			
Deciduous Cover				
None	+			
1 - 5%	-			
6 -25	-			
26 -50	0			
51 -75	0			
76 -100	-			
Tree Cover	+	.031	.017	
None	-			-1.471
1 -10%	-			0.466
11 -25	0			0.509
26 -50	0			0.707
50+	0			0.523
1st Major Tree		.069	.063	
None	+			0.273
Populus trem.	-			-0.415
P. balsam.	-			-1.247
Picea glauca	-			-0.854
Pinus contorta	+			0.591
2nd Major Tree		.013	.026	
None	+			-0.211
Populus trem.	0			0.265
P. balsam.	-			0.350
Picea glauca	-			-0.157
Pinus contorta	0			0.840
Shrub Cover		.057	.049	
None	0			-0.343
1 - 5%	+			0.167
6 -25	+			-0.110
26 -50	-			-0.225
51 -75	-			-0.189
76+	0			0.547
1st Major Shrub		0.121	.021	
None	-			-1.768
Rosa spp.	0			.012
Symphoricarpos spp.	-			- .073
Shepherdia canad.	0			.013
Eleagnus com.	-			-0.467
Amelanchier alni.	-			-0.342
Potentilla fru.	-			-0.569
Picea glauca	+			0.388
Other	-			0.149
2nd Major Shrub		.077	.014	
None	+			0.494
Rosa spp.	0			-0.187
Symphoricarpos spp.	-			-0.119
Shepherdia canad.	0			.012
Eleagnus com.	0			-0.318
Amelanchier alni.	-			- .057
Potentilla fru.	-			.031
Picea glauca	0			- .074
Other	+			0.634
Herb Cover		.010	.022	
None	0			-1.853
1 - 5%	0			-0.327
6 -25	0			0.109
26 -50	0			.040
51 -75	0			.090
76+	0			0.120
Grass Cover		0.113	.027	
None	0			0.400
1 - 5%	-			-0.262
6 -25	0			.077
26 -50	0			-0.112
51 -75	+			.070
76+	+			1.686

Table 3.9 continued.

	Direction of Response	eta	beta	MCA Coefficient
1st Major Grass		.091	.043	
None				
Calamagrostis spp.	-			0.199
Agropyron spp.	+			-0.518
Danthonia spp.	0			-1.362
Festuca spp.	+			0.469
Koeleria crist.	0			-0.655
Stipa spp.	0			-0.255
Other	0			-0.571
2nd Major Grass				
None	0			
Calamagrostis spp.	-			
Agropyron spp.	+			
Danthonia spp.	+			
Festuca spp.	+			
Koeleria crist.	-			
Stipa spp.	+			
Other	-			
Density of Forest Under				
0%	0			
1 -20	0			
21 -40	+			
41 -60	0			
61 -80	0			
81+	-			
Not in forest	+			
Amount of Grassland Duff		.098	.023	
0%	-			- .016
1 -20	0			- .067
21 -40	+			0.427
41 -60	+			0.743
61 -80	+			0.995
81 -100	0			2.343
Not on grassland	-			
Potentilla fru. Cover				
0 per 45 m^2	-			
1 - 5	+			
6 -10	+			
11 -20	+			
21 -30	0			
30+	0			
Not on grassland	-			
Forest Deadfall				
0%	-			
1 -20	+			
21 -40	-			
41 -60	-			
61 -80	-			
81+	0			
Not in forest	+			
Distance to Grassland		.045	.006	
0 metres	+			-0.212
1 -20	-			-0.156
21 -50	-			0.485
51 -100	+			.055
101 -200	0			- .076
200+	-			.043
Distance to Cover		.043	0.135	
0 metres	-			1.423
1 -20	0			1.522
21 -50	+			1.104
51 -100	+			1.198
101 -200	+			1.199
200+	+			-0.475
Slope		.067	.040	
0 -10°	+			0.346
11 -20	-			-0.267
21 -30	-			-0.671
30+	-			-1.008
Aspect		0.137	.065	
No slope	+			0.981
N	-			-0.481
S	0			0.315
E	0			-0.220
W	-			-0.526

1 Based on X^2 tests with the hypothesis that occurrance of fecal groups follow expected patterns ($p \leq .05$) (+ = sign occurs more frequently than expected; 0 = sign occurs as frequently as expected, or category too small for calculation of confidence intervals; - = sign occurs less frequently than expected).

The relative importance of the 9 most important variables when all other variables were "held constant"., were, in descending order, distance to cover, aspect, first major (dominant) tree, shrub cover, first major grass species, slope, grass cover, second major tree species and herb cover. There were strong positive associations with distance close to cover, with slight or no slopes or south facing aspects, either pine tree cover or no trees at all, with a very light shrub cover, with Festuca spp., with heavy grass cover. There were strong negative associations with distances greater than 200 m from cover, north east and west aspects, aspen poplar and spruce trees, dense shrub cover, with either Festuca spp. or Calamagrostis spp., with very slight or no slope and light grass cover.

3.42 Spring/Summer Patterns

3.421 General Patterns

Elk made at least some use of all canopy cover types and all vegetation associations during the combined spring/summer period (Table 3.7 and Table 3.8). However, in spring, they avoided Populus balsamifera wetlands and in summer, they avoided areas with 50 - 75% deciduous or coniferous tree cover (although both these areas combined constituted <1.0% of all plots sampled). Pellet groups representing spring/summer deposition occurred on 28% of the

pellet group plots. The probability of two individual elk attempting to utilize the same plot over the length of the study for these two seasons was 139% higher than it would have been if elk were the perfect generalist (Table 3.1), although the probability was somewhat less in spring than in summer. On average an elk in the spring/summer period would have found that there had been 1.61 other elk in any one plot it was located in, although there would have been twice as many in summer as spring.

With snowmelt and subsequent spring/summer availability of many habitat types, preferences in this period were strong for or against only one cover type (Table 3.7). Only coniferous forest with or without scattered deciduous had more pellet groupings than expected. When the two seasons were distinguished however, further definitions can be made. Although the type, coniferous forest with or without scattered deciduous trees, continued to have more pellet groupings than expected, mixed forest was avoided in spring and open grassland and areas with 30 - 50% deciduous or coniferous cover were avoided in summer. However, grasslands and coniferous forests contained the most pellet groupings in spring and grasslands and mixed forest contained most pellet groupings in summer.

These distribution patterns were defined further by a consideration of the plant associations (Table 3.8). Sign occurred more frequently than expected in 4 types: pine

forests, both parkland and slope types, pine aspen and aspen pine. Any types that had large quantities of spruce had less pellet groupings than expected. Non-bench grasslands and shrublands were also avoided. When the two seasons were separated, there were strong preferences for certain plant associations in spring than in summer, with 9 types having more or less pellet groupings than expected in spring and only 6 in summer. Aspen, aspen spruce and shrublands had less than expected in spring but not in summer. Also, grassland bench areas were preferred in spring but were neither preferred nor avoided in summer.

Abundance of fecal groupings was also used to test preference or avoidance of individual features of the environment. There were not strong preferences either for or against any individual environmental features. Fecal groupings occurred more frequently than expected on plots with a light amount of pine cover, a fairly light shrub cover especially of buffalo berry (Shepherdia canadensis) and spruce shrubs, a light amount of grass cover, a forest understory of 21 - 40%, a light amount of forest deadfall, a slight or no slope and south facing aspects. Fewer pellet groupings than expected were located in plots with either none or medium to heavy amounts of conifer cover, spruce cover, heavy shrub cover, especially of shrubby cinquefoil, very light grass cover, secondary grass species of Koeleria cristata, no duff on grassland habitats, heavy deadfall, 21

Table 3.10 Total Spring/Response of elk to individual features of habitat.
summer

Multiple Relationships: Generalized R^2 = 44 ; Multiple R = 60 ; Multiple R^2 = 35

	Direction of Response[1]	eta	beta	MCA Coefficient
Conifer Cover				
None	-			
1 - 5%	0			
6 -25	+			
26 -50	-			
51 -75	-			
76+	-			
Deciduous Cover				
None	0			
1 - 5%	0			
6 -25	0			
26 -50	0			
51 -75	0			
76 -100	0			
Tree Cover		0.169	0.397	
None	0			
1 -10%	0			-1.207
11 -25	0			0.481
26 -50	0			0.464
50+	0			0.453
				0.321
1st Major Tree		0.160	.097	
None	-			
Populus trem.	0			0.581
P. balsam.	0			-0.266
Picea glauca	-			-0.144
Pinus contorta	+			-0.301
				-0.134
2nd Major Tree		.055	.002	
None	-			
Populus trem.	0			- .030
P. balsam.	0			.011
Picea glauca	0			0.293
Pinus contorta	+			.025
				.026
Shrub Cover		.038	0.184	
None	0			
1 - 5%	0			1.272
6 -25	+			.024
26 -50	-			0.125
51 -75	-			0.143
76+	0			- .055
				-0.285

	Direction of Response	eta	beta	MCA Coefficient
1st Major Shrub		.080	.018	
None	-			
Rosa spp.	0			- .036
Symphoricarpos spp.	0			-0.105
Shepherdia canad.	+			0.469
Eleagnus com.	0			0.178
Amelanchier alni.	0			-0.679
Potentilla fru.	-			.069
Picea glauca	+			-0.199
Other	0			.036
				.008
2nd Major Shrub		.052	.018	
None	0			
Rosa spp.	0			-0.234
Symphoricarpos spp.	0			- .045
Shepherdia canad.	+			0.228
Eleagnus com.	0			-0.128
Amelanchier alni.	0			-0.862
Potentilla fru.	0			.097
Picea glauca	0			- .208
Other	0			- .082
				.086
Herb Cover		.028	.042	
None	0			
1 - 5%	0			.015
6 -25	0			-0.406
26 -50	0			.024
51 -75	0			- .041
76+	0			-0.287
				-0.965
Grass Cover		.060	.044	
None	0			
1 - 5%	-			0.685
6 -25	+			.023
26 -50	0			- .013
51 -75	0			- .055
76+	0			-0.280
				-0.967

Table 3.10 continued.

	Direction of Response	eta	beta	MCA Coefficient
1st Major Grass		0.176	0.336	
None	0			.256
Calamagrostis spp.	0			0.366
Agropyron spp.	0			-1.529
Danthonia spp.	0			-1.055
Festuca spp.	0			-1.570
Koeleria crist.	0			-0.961
Stipa spp.	0			-1.129
Other	0			0.459
2nd Major Grass				
None	0			
Calamagrostis spp.	0			
Agropyron spp.	0			
Danthonia spp.	0			
Festuca spp.	0			
Koeleria crist.	-			
Stipa spp.	+			
Other	-			
Density of Forest Under				
0%	0			
1 -20	0			
21 -40	+			
41 -60	0			
61 -80	0			
81+	-			
Not in forest	0			
Amount of Grassland Duff		0.221	0.184	
0%	-			1.120
1 -20	0			0.918
21 -40	0			1.355
41 -60	0			-0.322
61 -80	0			-0.271
81 -100	0			-0.216
Not on grassland	0			
Potentilla fru. Cover				
0 per 45 m^2	0			
1 - 5	0			
6 -10	0			
11 -20	0			
21 -30	-			
30+	0			
Not on grassland	0			

	Direction of Response	eta	beta	MCA Coefficient
Forest Deadfall				
0%	0			
1 -20	+			
21 -40	0			
41 -60	0			
61 -80	-			
81+	0			
Not in forest	0			
Distance to Grassland		0.142	.035	
0 metres	0			.060
1 -20	0			-0.210
21 -50	-			-0.159
51 -100	0			-0.190
101 -200	0			-0.112
200+	0			0.368
Distance to Cover		0.193	0.593	
0 metres	0			0.634
1 -20	0			1.645
21 -50	0			2.000
51 -100	0			1.864
101 -200	0			1.381
200+	-			-0.515
Slope		.046	.009	
0 -10°	+			.061
11 -20	0			.031
21 -30	-			-0.174
30+	-			-0.319
Aspect		0.143	.095	
No slope	0			0.849
N	-			-0.182
S	+			-0.114
E	0			-0.113
W	0			-0.180

* Based on X^2 tests with the hypothesis that occurrance of fecal groups follow expected patterns ($p \leq .05$) (+ = sign occurs more frequently than expected; 0 = sign occurs as frequently as expected, or category too small for calculation of confidence intervals; - = sign occurs less frequently than expected).

- 50 m distant from grassland and more than 200 m from cover, slopes greater than 20° and north-facing aspects. Appendix A shows the response of elk within each season. Tree cover dominated by pine and with either pine or aspen as secondary species becomes much more important in summer. Grassland features become less important in summer. The degree of slope and aspect were also less important in summer.

A reduced set of individual environmental features accounted for 44% of the variation in distributions of the pellet groups (generalized R^2, Table 3.10). Of the fourteen variables examined in the model, seven accounted for more than 10% of this variation. These were, in descending order, amount of grassland duff, distance to cover, first major grass species, tree cover, first major tree species, aspect and distance to grassland. Neither slope, shrub characteristics, herb or grass cover contributed much to explaining the variation.

The relative importance of the seven most important variables, when all other variables were "held constant" were, in descending order: distance to cover, tree cover, shrub cover, amount of grassland duff, first major tree species, aspect and grass cover. There were strong positive associations with a light tree cover, no shrub cover or a light shrub cover of Symphoricarpos albus or Shepherdia canadensis, no grass cover or a light cover of Calamagrostis

spp., no grassland duff or a light amount, more than 200 m from grassland habitats or if on the grassland, within 200 m of cover, and no aspect or slope. There were strong negative associations with no tree cover or cover dominated by aspen or spruce, heavy shrub cover of Rosa, Eleagnus commutata or Potentilla fruticosa, heavy herb or grass cover, grass cover dominated by Fescue or Agropyron, heavy amounts of grassland duff, within 100 m of the grassland habitats or if on the grassland more than 200 m from cover and slopes over 20°.

3.422 Annual and Regional Patterns

Figures 3.6 to 3.13 show the regional patterns of observed elk for two-week periods from May 1 to August 31, 1978, on the eastern one-half of the park. During early May, (Fig. 3.6) there was still substantial migration occurring from the northeastern part of the park (area FH) to other areas. In fact, the large grouping of 45 animals in area STP was observed moving a distance of nearly 4 km in less than 3 hr. By late May, all open areas that are close to tree cover had fairly even distributions of elk (with the exception of area SC). The number of sightings during the month of May was substantial (totalling 1,071). The period May 1 to May 15 did not receive as intense a frequency of observation as the rest of the summer because of inaccessibility due to inclement weather. During June (Fig. 3.8 and 3.9) sightings reduced substantially (total = 276 or only 26% of the May

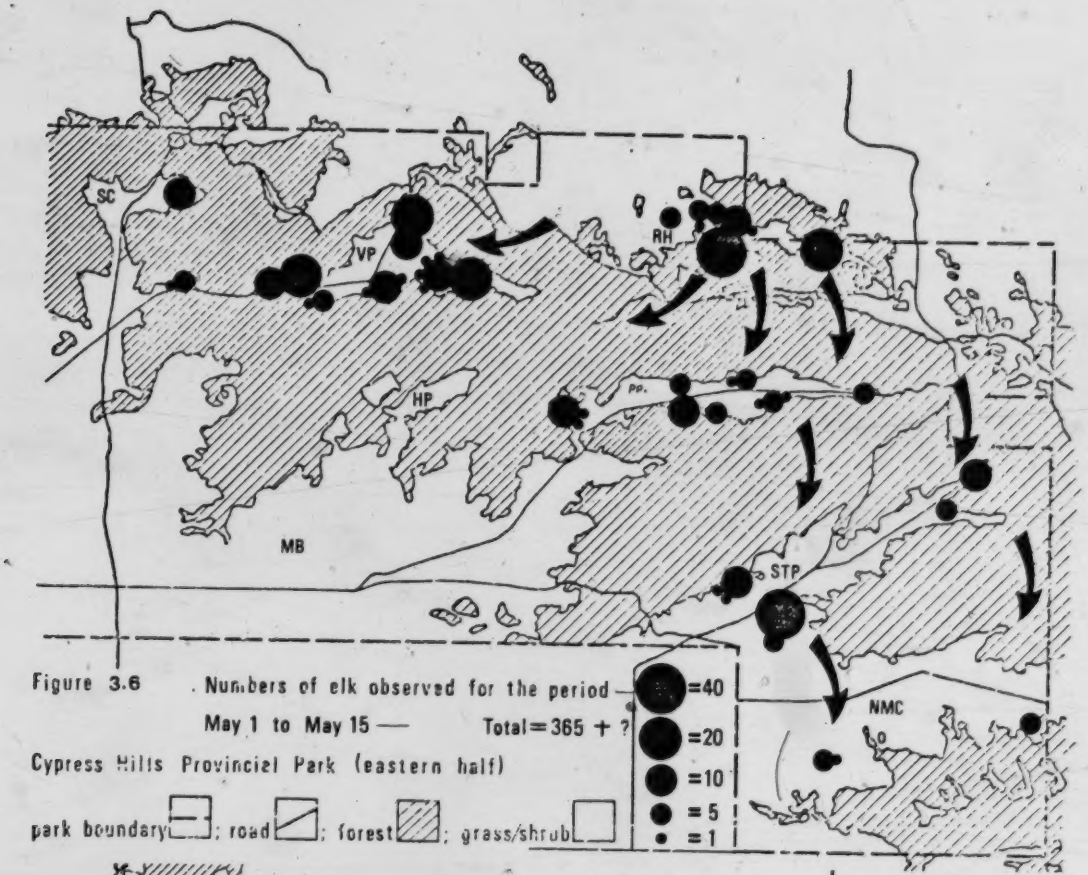

Figure 3.6 . Numbers of elk observed for the period May 1 to May 15 — Total = 365 + ?

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

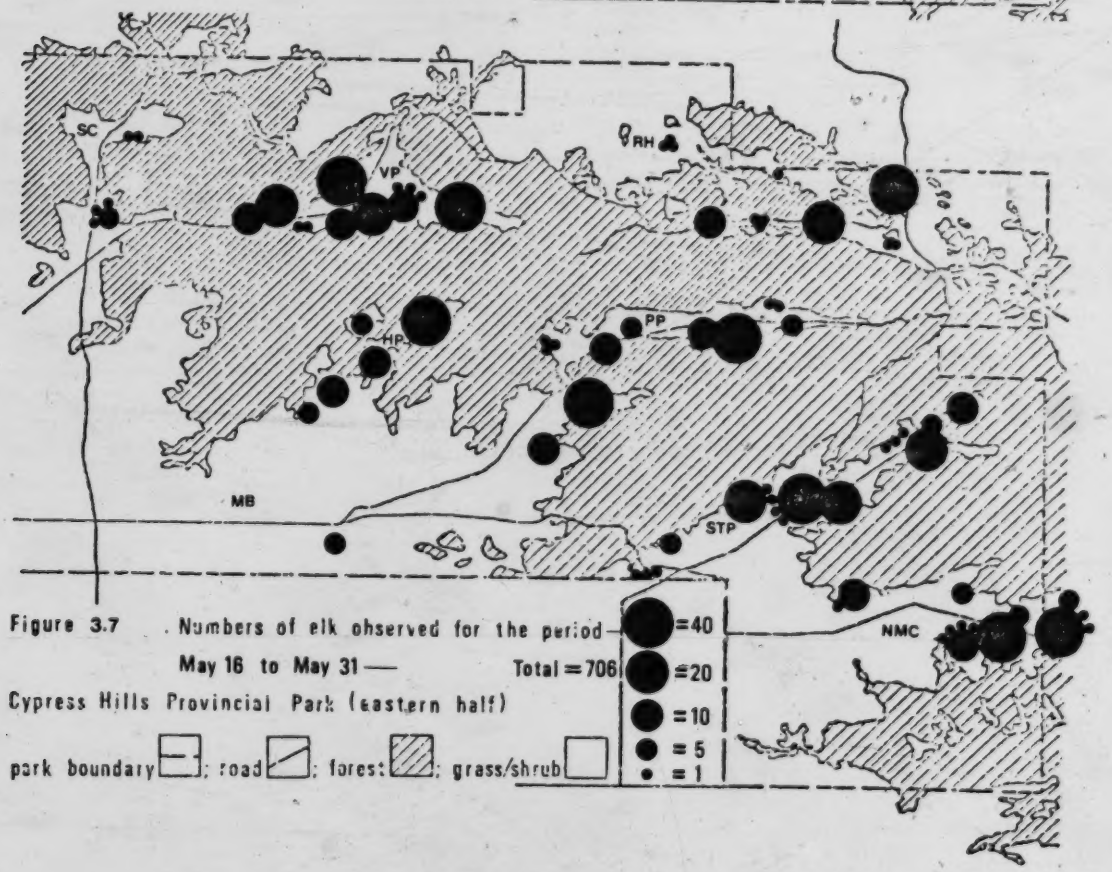

Figure 3.7 . Numbers of elk observed for the period May 16 to May 31 — Total = 706

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

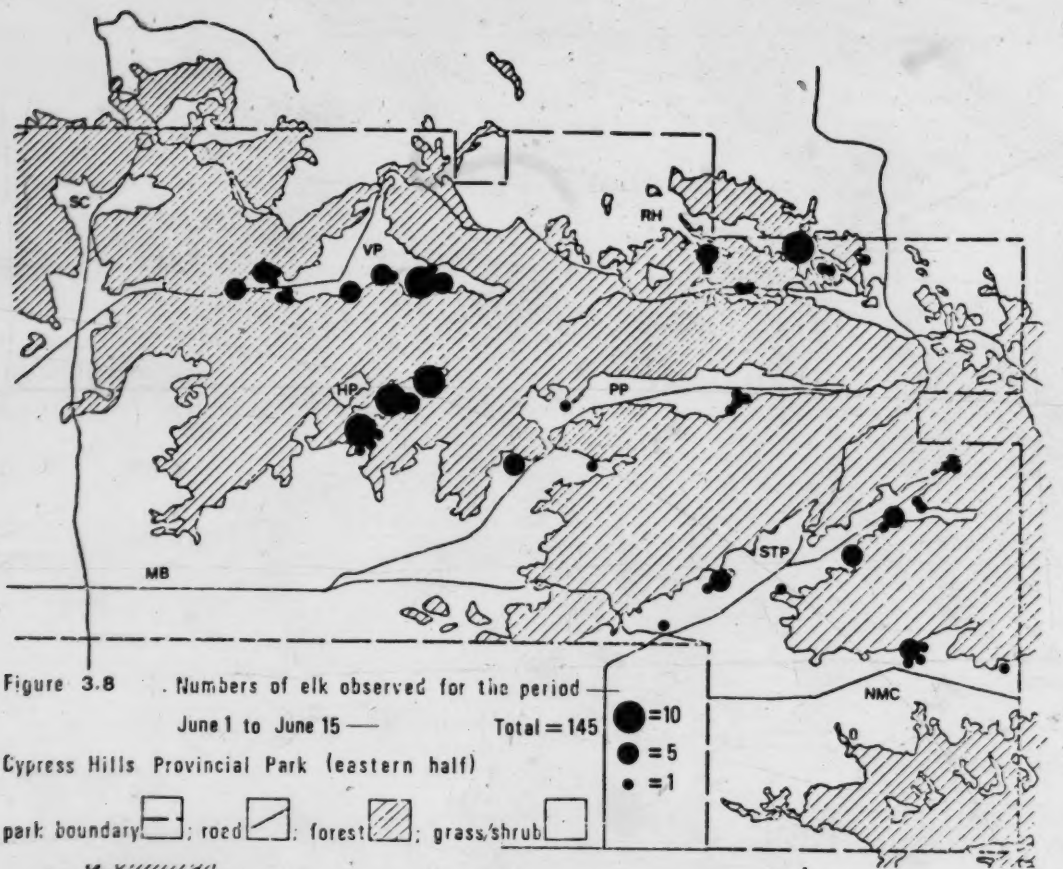

Figure 3.8 . Numbers of elk observed for the period June 1 to June 15 — Total = 145

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

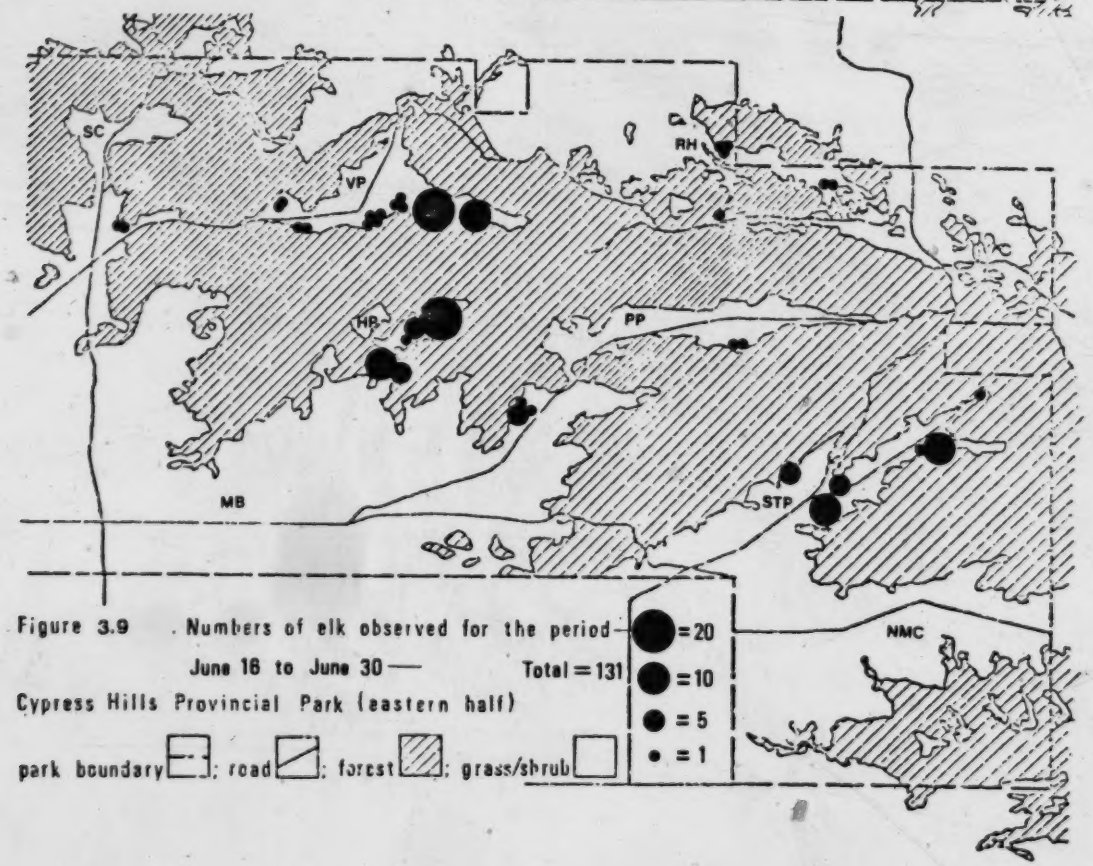

Figure 3.9 . Numbers of elk observed for the period June 16 to June 30 — Total = 131

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

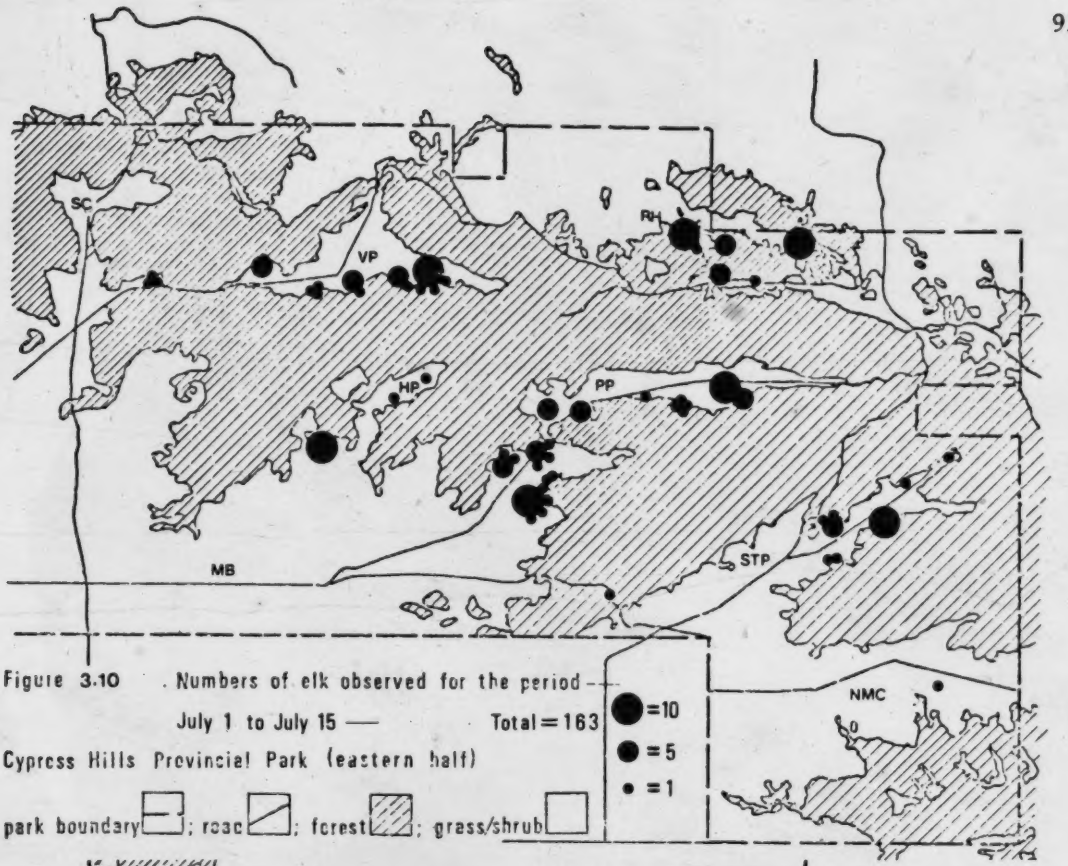

Figure 3.10 . Numbers of elk observed for the period July 1 to July 15 — Total = 163

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

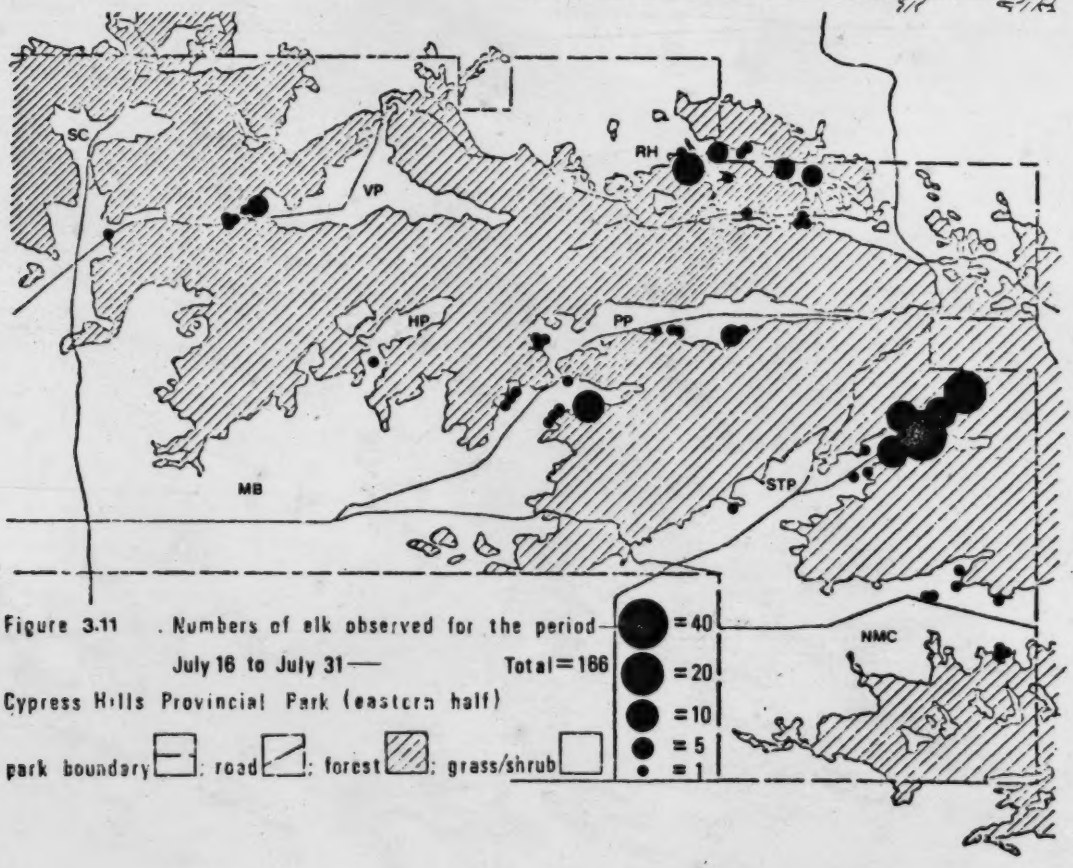

Figure 3.11 . Numbers of elk observed for the period July 16 to July 31 — Total = 166

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

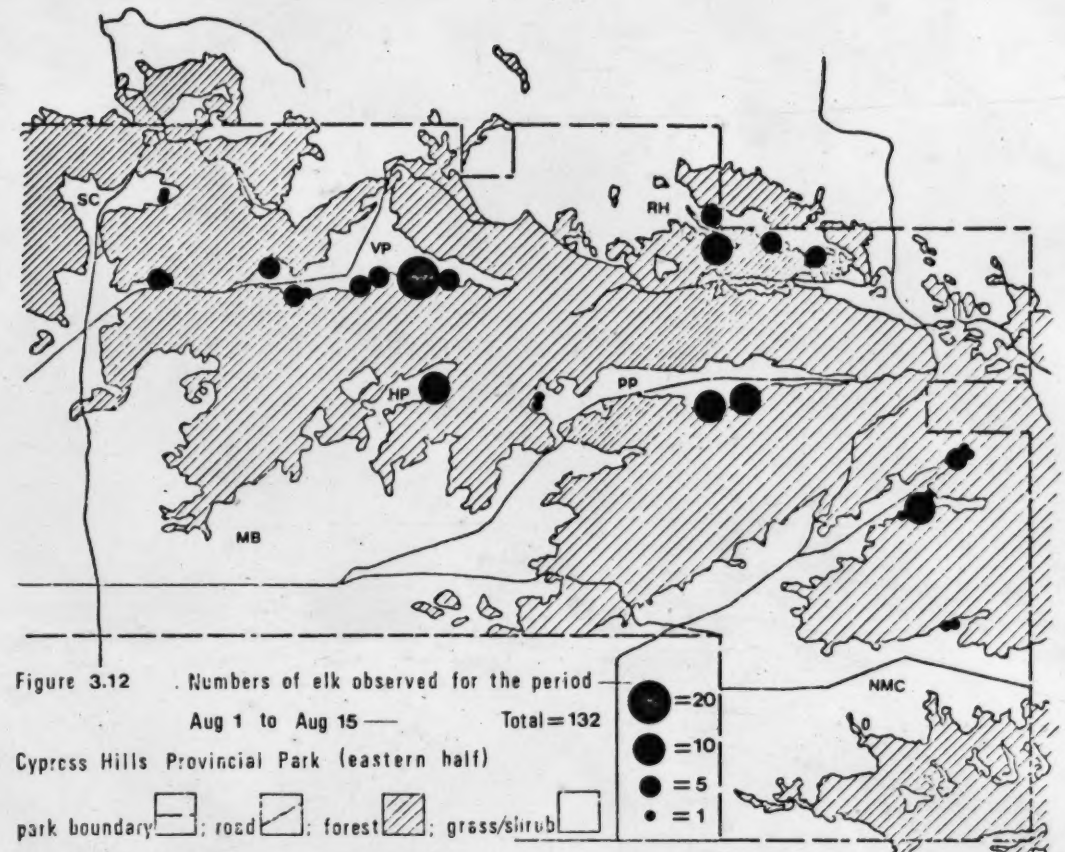

Figure 3.12 . Numbers of elk observed for the period Aug 1 to Aug 15 — Total=132

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

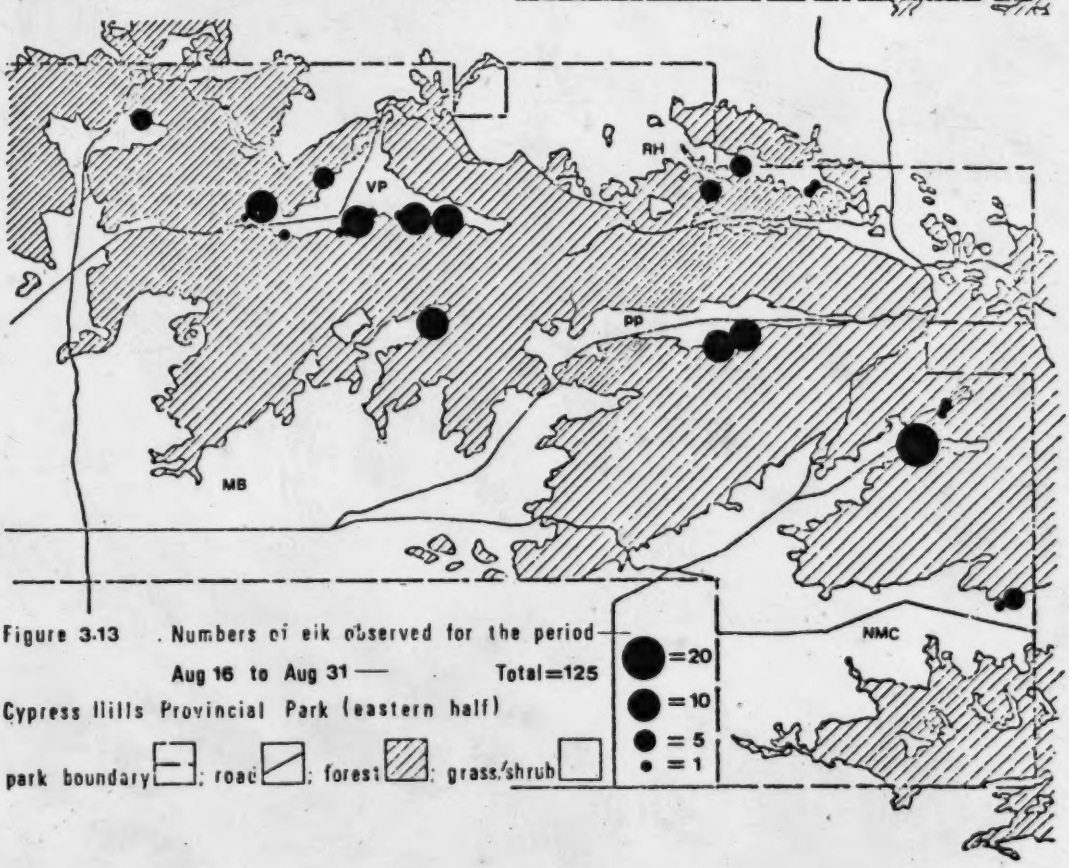

Figure 3.13 . Numbers of elk observed for the period Aug 16 to Aug 31 — Total=125

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

sightings) possibly as a result of calving, green-up, introduction of cattle into the park (in late May) and/or increased tourist traffic. However, there also appeared to be some regional changes. Although areas VP and HP remained high in sightings, there was a distinct decrease in sightings in areas PP, NMC and RH which continued to decrease throughout the month. There was a less distinct decrease in STP in early June and a gradual increase in late June. In July, the increase in sightings in STP continued until the more remote parts of this area contained 57% of all elk sightings for the last two weeks in July. Areas VP and HP greatly decreased in sightings during late July but there were fairly large increases in areas PP and RH. NMC continued to remain low in sightings. During August there appearred to be a more even distribution with the exception of NMC (Figs. 3.12 and 3.13). The western one-half of the park was also surveyed on the same intensity but less than 15 elk were observed there from May 15 to August 31.

Two periods were compared on an annual basis - May 6 to May 12 and July 16 to July 31 in 1977 and 1978 (Figs. 3.14, 3.15, 3.16 and 3.17). The elk were much more evenly distributed at an earlier date in 1977 than in 1978 (although area RH was not surveyed in 1977) (Figs. 3.14 and 3.15). Even NMC had substantial quantities of elk. No major movements were observed during this period in 1977 but movements were observed in 1978.

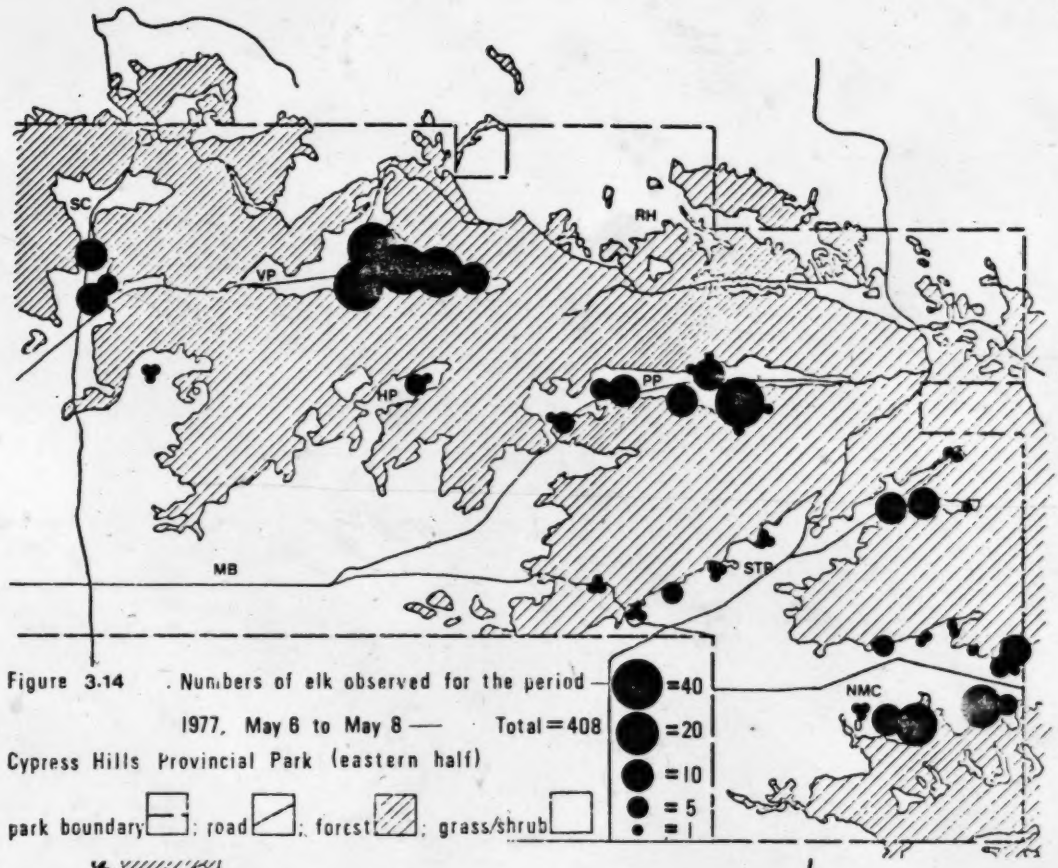

Figure 3.14 . Numbers of elk observed for the period — 1977, May 6 to May 8 — Total = 408

Cypress Hills Provincial Park (eastern half)

park boundary ; road ; forest ; grass/shrub

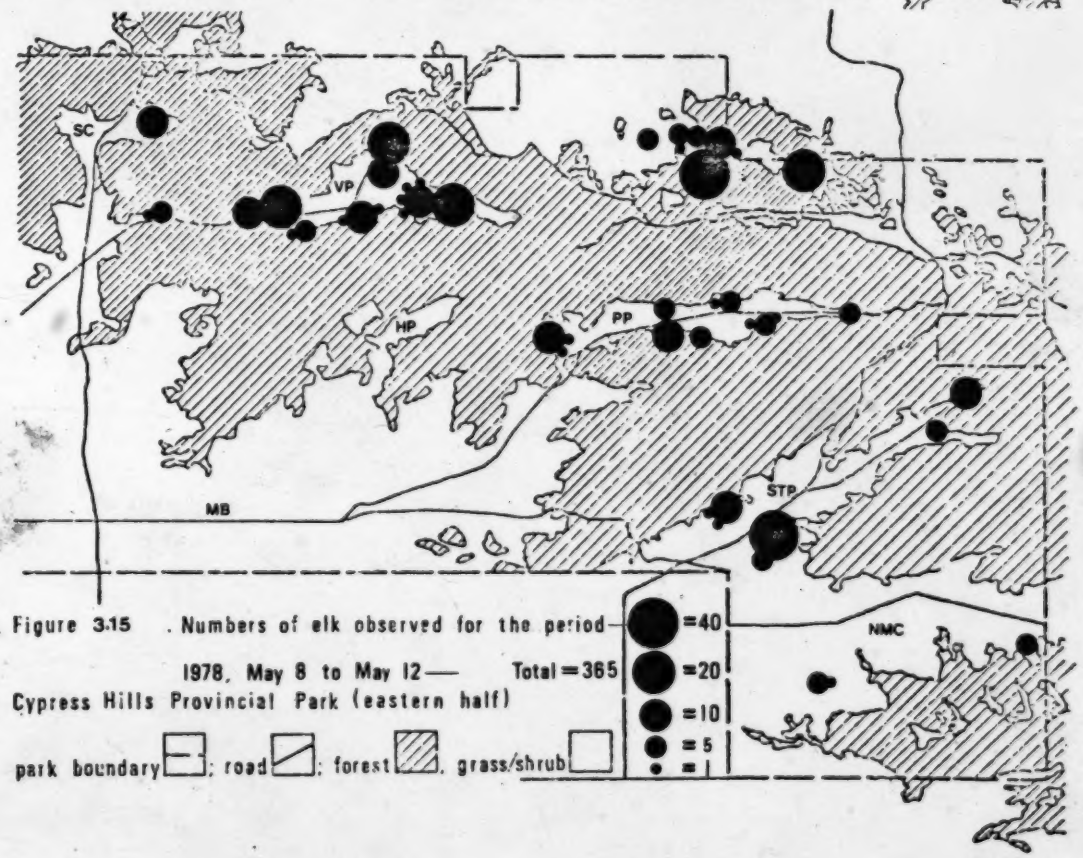

Figure 3.15 . Numbers of elk observed for the period — 1978, May 8 to May 12 — Total = 365

Cypress Hills Provincial Park (eastern half)

park boundary ; road ; forest ; grass/shrub

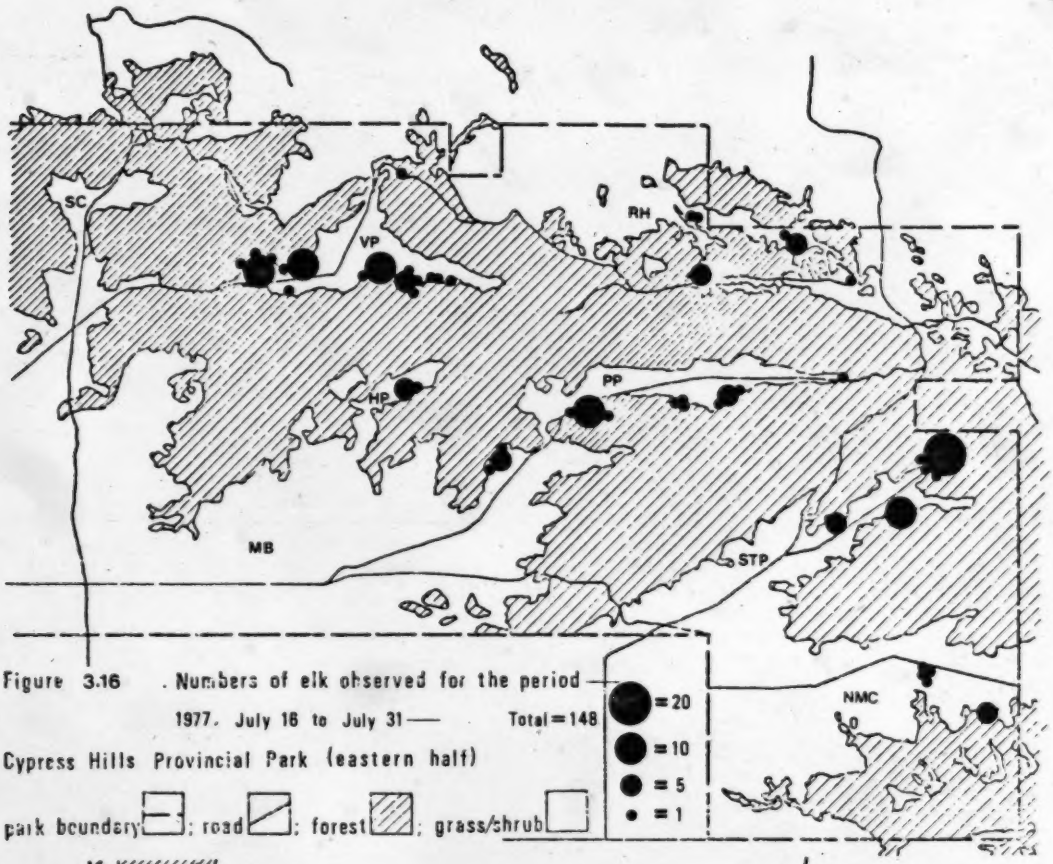

Figure 3.16 . Numbers of elk observed for the period 1977, July 16 to July 31 — Total = 148

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

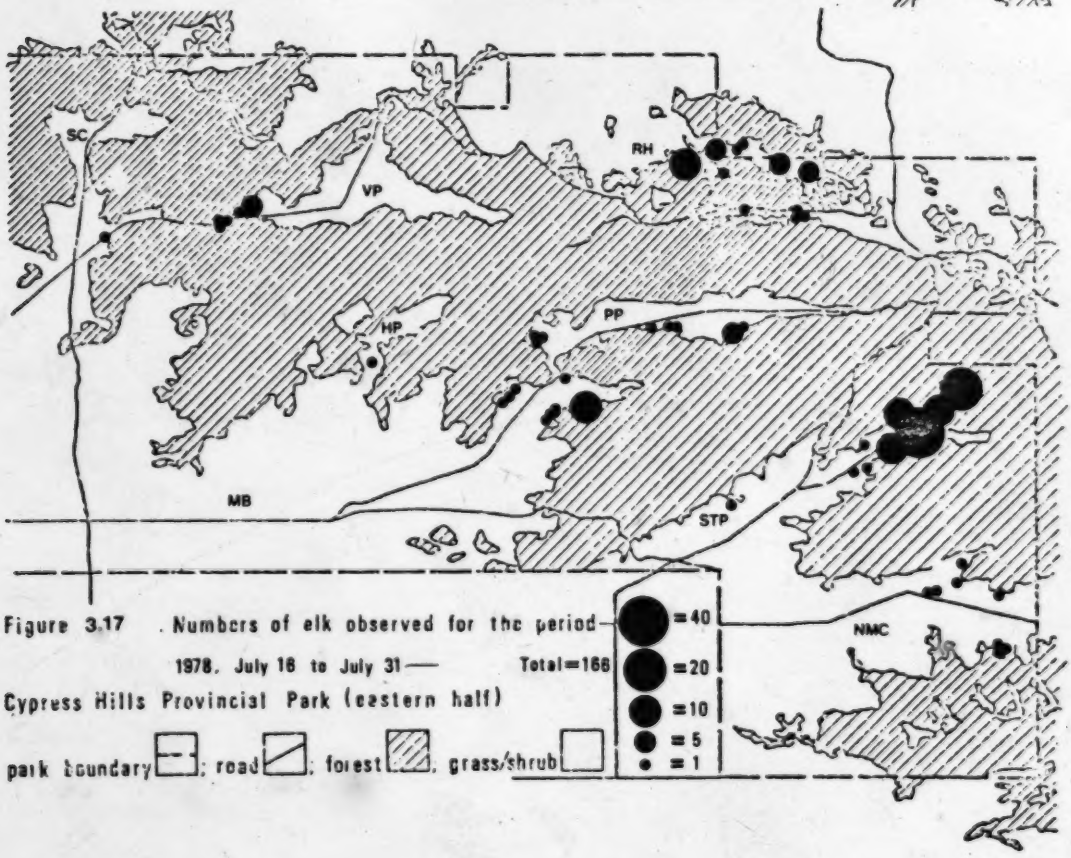

Figure 3.17 . Numbers of elk observed for the period 1978, July 16 to July 31 — Total = 168

Cypress Hills Provincial Park (eastern half)

park boundary; road; forest; grass/shrub

In the last two weeks of July of 1977, area VP was used much more intensively than in 1978 (Figs. 3.16 and 3.17). More remote areas of the park (especially areas STP and RH) seemed to have a greater proportion of sightings in 1978 than in 1977.

Annual changes in direction of response to canopy cover types (Table 3.11) were substantial. There was an avoidance of the open grassland areas in 1978 whereas in 1977 there is neither preference nor avoidance. When more detailed vegetation types were examined (Table 3.12) there were 8 associations that elk had significant affitities for or against in 1978 but in 1977 there were only 2. Aspen-pine and pine-spruce were preferred in 1978 but were avoided in 1977 (although not to a significant degree) and shrubland was avoided in 1978 but was preferred in 1977 (although not to a significant degree). Regional changes for various canopy cover types and vegetation associations were very slight (Tables 3.11 and 3.12).

3.43 Fall/Winter Patterns

3.431 General Patterns

During the fall-winter period elk made use of all canopy cover types and nearly all vegetation associations with the exception of poplar wetlands (Table 3.8 and 3.9). Pellet groups representing the fall-winter of 1976-77

Table 3.11 Direction of response: annual and regional elk summer preferences for various canopy cover types.

Canopy Cover Type	Overall Direction of Response (2 years and all areas)	Annual Direction of Response 1977	Annual Direction of Response 1978	Regional Direction of Response[1]
1. Grassland, 1/3 of area in tree cover	-[2](0.8)[3]	0(1.0)	-(0.6)	0(0.5)
2. 30-50% deciduous or coniferous cover	-(0.2)	0(0.4)	0(0.9)	0(0.0)
3. 50-75% deciduous or coniferous cover	0(0.0)	0(0.0)	0(0.0)	0(0.0)
4. Fairly continuous cover with frequent openings	0(0.8)	0(1.0)	0(0.8)	0(0.9)
5. Deciduous forest with or without scattered conifer	0(1.1)	0(1.5)	0(1.0)	0(1.2)
6. Mixed forest	0(1.0)	0(0.8)	0(1.1)	+(1.4)
7. Coniferous forest with or without scattered deciduous	+(1.6)	+(1.5)	+(1.7)	+(1.7)
8. Closed canopy conifer	0(1.0)	0(0.8)	0(1.0)	0(1.2)
9. Dense pine - old burn	0(0.8)	0(0.5)	0(1.2)	0(0.0)

1 This is based on transects 1-17, all of which were located on or adjacent to the Viewpoint Plateau (see Fig. 3.1 for locations).

2 Based on chi-square tests of the various data sets on the null hypothesis that observed distribution = expected distribution (p .05) (+ = fecal groupings occur more frequently than expected; - = fecal groupings occur less frequently than expected; 0 = fecal groupings occur as frequently as expected or category too small for calculation of confidence limits.

3 Taken from Table 3.8. (Affinity Index)

Table 3. 12 Direction of response: annual and regional elk summer preferences for various vegetation associations.

Vegetation Association	Overall Direction of Response (2 years and all areas)	Annual Direction of Response		Regional Direction of Response[3]
		1977	1978	
Parklands				
Pine	+[1](2.9)[2]	0(2.5)	+(3.0)	0(4.3)
Pine Aspen	0(0.7)	0(0.4)	0(1.1)	0(0.6)
Aspen	0(0.8)	0(1.0)	0(0.6)	0(1.0)
Slopes				
Pine	0(1.1)	0(1.1)	+(1.6)	0(1.1)
Pine Aspen	+(2.1)	+(1.9)	+(1.9)	+(2.4)
Aspen Pine	+(1.6)	0(0.8)	+(2.2)	+(2.0)
Aspen	0(0.8)	0(0.9)	0(1.0)	0(0.6)
Aspen Spruce	0(1.1)	0(0.9)	-(0.3)	0(0.9)
Spruce Aspen	-(0.8)	0(0.7)	-(0.4)	0(0.6)
Pine Spruce	0(1.3)	0(0.8)	+(1.8)	+(1.8)
Spruce Pine	0(0.5)	0(0.7)	0(0.3)	0(0.6)
Wetlands				
Spruce	-(0.4)	-(0.3)	0(0.4)	-(0.1)
Poplar	0(2.4)	0(0.0)	0(0.0)	0(2.9)
Open Areas				
Grassland Bench	0(1.0)	0(1.0)	0(0.7)	0(0.7)
Grassland non-bench	-(0.5)	0(0.6)	0(0.6)	-(0.3)
Shrubland	0(0.6)	0(1.3)	-(0.1)	0(0.6)

1 Based on chi-square tests of the various data sets on the null hypothesis that observed distributions = expected distribution (p .05) (+ = fecal groupings occur more frequently than expected; - = fecal groupings occur less frequently than expected; 0 = fecal groupings occur as frequently as expected or category too small for calculation of confidence limits.

2 Taken from Table 3.8 (Affinity Index).

3 This is based on transects 1-17, all of which were located on or adjacent to the Viewpoint Plateau (see Fig. 3.1 for locations).

Table 3.13 Fall/Winter Response of elk to individual features of habitat.

Multiple Relationships: Generalized R^2 = 35 ; Multiple R = 54 ; Multiple R^2 = 29

	Direction of Response[1]	eta	beta	MCA Coefficient
Conifer Cover				
None	+			
1 - 5%	-			
6 -25	-			
26 -50	0			
51 -75	0			
76+	0			
Deciduous Cover				
None	+			
1 - 5%	0			
6 -25	-			
26 -50	0			
51 -75	-			
76 -100	0			
Tree Cover		.065	.287	
None	+			-1.027
1 -10%	0			0.505
11 -25	-			0.290
26 -50	0			0.451
50+	0			0.379
1st Major Tree		.077	.080	
None	+			0.468
Populus trem.	-			-0.290
P. balsam.	0			-0.604
Picea glauca	-			-0.399
Pinus contorta	0			.050
2nd Major Tree		.025	.012	
None	+			- .086
Populus trem.	0			0.147
P. balsam.	0			0.258
Picea glauca	-			- .060
Pinus contorta	0			0.254
Shrub Cover		.032	.020	
None	0			- .053
1 - 5%	+			.068
6 -25	0			- .029
26 -50	-			-0.133
51 -75	-			.010
76+	0			- .081

	Direction of Response	eta	beta	MCA Coefficient
1st Major Shrub		0.137	.026	
None	0			-1.03
Rosa spp.	0			- .069
Symphoricarpos spp.	0			- .058
Shepherdia canad.	0			.071
Eleagnus com.	0			- .063
Amelanchier alni.	-			-0.162
Potentilla fru.	-			-0.371
Picea glauca	+			0.177
Other	-			0.157
2nd Major Shrub		.079	.027	
None	+			0.515
Rosa spp.	0			-0.120
Symphoricarpos spp.	+			- .029
Shepherdia canad.	-			-0.173
Eleagnus com.	0			0.353
Amelanchier alni.	-			.074
Potentilla fru.	-			-0.167
Picea glauca	0			-0.115
Other	0			0.248
Herb Cover		.005	.009	
None	0			- .098
1 - 5%	+			.092
6 -25	0			.021
26 -50	0			- .001
51 -75	0			-0.118
76+	0			0.477
Grass Cover		.094	.005	
None	0			0.168
1 - 5%	-			-0.127
6 -25	-			.061
26 -50	+			.008
51 -75	+			-0.121
76+	0			-0.105

Table 3.13 continued.

	Direction of Response	eta	beta	MCA Coefficient
1st Major Grass		0.175	0.145	
None				nd
Calamagrostis spp.	-			0.211
Agropyron spp.	+			-0.701
Danthonia spp.	0			-1.302
Festuca spp.	+			0.386
Koeleria crist.	0			-0.443
Stipa spp.	0			-0.645
Other	0			-0.100
2nd Major Grass				
None	0			
Calamagrostis spp.	-			
Agropyron spp.	+			
Danthonia spp.	+			
Festuca spp.	+			
Koeleria crist.	0			
Stipa spp.	+			
Other	0			
Density of Forest Under				
0%	0			
1 -20	0			
21 -40	-			
41 -60	-			
61 -80	-			
81+	-			
Not in forest	+			
Amount of Grassland Duff		0.152	.037	
0%	-			-0.283
1 -20	0			.044
21 -40	+			.091
41 -60	+			0.571
61 -80	+			0.750
81 -100	0			0.935
Not on grassland	-			-0.089
Potentilla fru. Cover				
0 per 45 m^2	0			
1 - 5	+			
6 -10	+			
11 -20	+			
21 -30	0			
30+	+			
Not on grassland	-			
Forest Deadfall				
0%	-			
1 -20	0			
21 -40	-			
41 -60	-			
61 -80	-			
81+	0			
Not in forest	+			
Distance to Grassland		.083	.029	
0 metres	+			- .035
1 -20	0			- .032
21 -50	0			0.270
51 -100	+			- .062
101 -200	0			-0.188
200+	-			0.275
Distance to Cover		.099	0.184	
0 metres	-			0.756
1 -20	0			0.734
21 -50	0			0.794
51 -100	+			0.904
101 -200	+			1.175
200+	+			-0.302
Slope		.053	.011	
0 -10°	+			.091
11 -20	-			- .047
21 -30	-			-0.245
30+	-			-0.207
Aspect		0.156	.071	
No slope	+			0.602
N	-			-0.264
S	0			0.120
E	0			-0.129
W	-			-0.235

* Based on X^2 tests with the hypothesis that occurrance of fecal groups follow expected patterns ($p \leq .05$) (+ = sign occurs more frequently than expected; 0 = sign occurs as frequently as expected, or category too small for calculation of confidence intervals; - = sign occurs less frequently than expected).

occurred on 40% of the pellet group plots.

The probability of intraspecific encounter during this general period was 178% higher than it would have been if elk were the perfect generalist but during the fall of 1977 the probability was 66% higher.

Sign occurred more frequently than expected in two canopy cover types, the grassland areas and coniferous forests with or without scattered deciduous. These two cover types occupied 38% of the total number of plots but contained 65% of the fall-winter pellet groupings and 68% of the fall groupings. Sign occurred on considerably fewer plots than expected in four canopy cover types in each period with fairly continuous cover with frequent openings, deciduous forest and mixed forest being common to both. During fall-winter of 1976-77 however, areas of 30% to 50% deciduous or coniferous cover were avoided and during the fall of 1977, dense pine/old burn type was avoided.

Eight vegetation associations received the same direction of response to a significant degree during both periods. parklands pine/aspen and grassland bench areas were preferred types while aspen, aspen/spruce, spruce/aspen, spruce wetlands, grassland nonbench and shrublands were avoided. In addition, during the fall-winter, parklands pine was preferred and parklands aspen was avoided while during the fall of 1977, pine spruce and spruce pine were avoided. The four types containing the four highest percentages of

pellet groupings occupied 45.5% of the total plots and contained 68% of total pellet groupings during fall-winter and 41% and 77% respectively for the fall period.

Chi-square tests performed on the environmental features and pellet group data (Tables 3.14 and 3.15) showed that sign occurred more frequently than expected on plots with no tree cover, a very light shrub cover of Shepherdia canadensis a very light herb cover, a medium to heavy grass cover dominated by Agropyron spp., Festuca spp. or Danthonia spp., a moderate amount of grassland duff, between 51-100 m from grassland areas if in cover, or greater than 51 m from cover if or the grasslands and slight to no slopes. Fall patterns differed only slightly in that there was a more dual preference for both non-treed areas and areas of heavy conifer cover or medium deciduous cover with an understory of rose or Picea glauca trees of shrub size, and a preference for areas somewhat closer to cover (>21 m). Under-utilized habitat features were light to medium tree cover, light conifer cover and medium deciduous cover, habitats dominated by Picea glauca or Populus tremuloides or containing Populus balsamifera, heavy shrub cover, especially of Amelanchier alnifolia, Potentilla fruticosa, light grass cover, a heavy density of forest understory, no grassland duff, a medium amount of forest deadfall, greater than 200 m from grassland communities, slopes over 10° and north and west facing aspects. Fall preferences were very

Table 3.14 Fall Response of elk to individual features of habitat.

Multiple Relationships: Generalized R^2 = 32 ; Multiple R = 50 ; Multiple R^2 = 25

	Direction of Response[1]	eta	beta	MCA Coefficient
Conifer Cover		.028	.020	
None	+			- .007
1 - 5%	-			-0.270
6 -25	0			0.101
26 -50	0			0.193
51 -75	+			0.593
76+	-			-0.389
Deciduous Cover				
None	+			
1 - 5%	-			
6 -25	-			
26 -50	+			
51 -75	0			
76 -100	0			
Tree Cover				
None	+			
1 -10%	-			
11 -25	-			
26 -50	0			
50+	+			
1st Major Tree		.027	.019	
None	+			-0.250
Populus trem.	-			0.126
P. balsam.	0			- .070
Picea glauca	-			- .059
Pinus contorta	0			0.133
2nd Major Tree				
None	+			
Populus trem.	0			
P. balsam.	0			
Picea glauca	-			
Pinus contorta	0			
Shrub Cover		.025	.207	
None	0			-0.384
1 - 5%	+			- .006
6 -25	+			.024
26 -50	-			-0.177
51 -75	0			-0.232
76+	-			-0.147
1st Major Shrub		.074	.020	
None	-			-0.753
Rosa spp.	+			0.119
Symphoricarpos spp.	-			- .076
Shepherdia canad.	-			-0.291
Eleagnus com.	0			-0.212
Amelanchier alni.	-			-0.247
Potentilla fru.	-			- .006
Picea glauca	+			-0.160
Other	-			0.128
2nd Major Shrub		.078	.049	
None	+			0.411
Rosa spp.	-			-0.135
Symphoricarpos spp.	-			- .015
Shepherdia canad.	-			-0.170
Eleagnus com.	0			nd
Amelanchier alni.	-			-0.132
Potentilla fru.	0			0.184
Picea glauca	0			-0.400
Other	+			0.668
Herb Cover		.009	.012	
None	0			-0.700
1 - 5%	0			.009
6 -25	+			.090
26 -50	0			- .036
51 -75	-			-0.160
76+	0			- .012
Grass Cover		0.100	.014	
None	0			- .049
1 - 5%	-			.021
6 -25	-			.041
26 -50	0			- .058
51 -75	+			- .089
76+	+			0.739

Table continued.

	Direction of Response	eta	beta	MCA Coefficient
1st Major Grass		.059	.057	
None				nd
Calamagrostis spp.	-			0.155
Agropyron spp.	+			-0.335
Danthonia spp.	0			-0.746
Festuca spp.	+			-0.125
Koeleria crist.	0			-0.881
Stipa spp.	0			-0.254
Other	-			-0.239
2nd Major Grass				
None	0			
Calamagrostis spp.	-			
Agropyron spp.	+			
Danthonia spp.	+			
Festuca spp.	+			
Koeleria crist.	0			
Stipa spp.	0			
Other	0			
Density of Forest Under		.029	0.130	
0%	0			-0.698
1 -20	0			.060
21 -40	0			.064
41 -60	0			0.244
61 -80	0			0.313
81+	-			0.308
Not in forest	+			
Amount of Grassland Duff		.089	0.219	
0%	0			0.791
1 -20	-			0.643
21 -40	0			0.965
41 -60	+			1.147
61 -80	+			1.316
81 -100	0			0.449
Not on grassland	-			-0.315
Potentilla fru. Cover		.069	.049	
0 per 45 m^2	-			0.435
1 - 5	+			0.428
6 -10	+			- .012
11 -20	+			0.882
21 -30	0			-0.960
30+	0			-0.198
Not on grassland	-			-0.112
Forest Deadfall		.029	.054	
0%	-			-0.424
1 -20	0			- .097
21 -40	-			-0.243
41 -60	0			.033
61 -80	0			- .009
81+	0			0.446
Not in forest	+			
Distance to Grassland		.038	.042	
0 metres	+			0.132
1 -20	-			0.152
21 -50	0			0.442
51 -100	+			0.255
101 -200	0			.031
200+	-			-0.386
Distance to Cover				
0 metres	-			
1 -20	0			
21 -50	+			
51 -100	+			
101 -200	+			
200+	+			
Slope		.028	.007	
0 -10°	+			.067
11 -20	-			- .041
21 -30	-			-0.256
30+	-			- .092
Aspect		0.132	0.155	
No slope	+			1.014
N	-			-0.247
S	-			-0.125
E	-			-0.324
W	0			-0.216

* Based on X^2 tests with the hypothesis that occurrance of fecal groups follow expected patterns ($p \leq .05$) (+ = sign occurs more frequently than expected; 0 = sign occurs as frequently as expected, or category too small for calculation of confidence intervals; - = sign occurs less frequently than expected).

similar except that the amount of forest understory or deadfall was not as critical.

A reduced set of environmental features accounted for 35% of the variation in pellet group numbers found on the plots in fall-winter and 32% in fall (generalized R^2, Tables 3.14 and 3.15). Of the fourteen variables, seven accounted individually for 8% or more of this variation; these were, in descending order, first major grass, aspect, amount of grassland duff, first major shrub, distance to cover, amount of grass cover and distance to grassland (eta^2 values, Table 3.14).

The relative importance of the seven most important variables, when all other variables were "held constant" were in descending order, tree cover, distance to cover, first major grass species first major tree, aspect, amount of grassland duff and distance to grassland communities. There were strong positve associations with light tree cover, distances of 101-200 m from cover, Festuca spp., no slope aspect heavy amounts of grassland duff, either 21 to 50 m from grassland communities or more than 200 m. There were strong negative associations with no tree cover, more than 200 m from cover, Agropyron or Stipa spp., Populus balsamifera or Picea glauca, north east and west aspects, no grassland duff, and distances of 101-200 m from grassland communities.

3.432 Annual and Regional Patterns

Aerial surveys conducted by parks staff from the 1972-73 winter to 1976-77 winter show that major elk concentrations have been on the eastern section of the park (Barrett 1972b, Gudmonson 1973, 1975b, 1975c, Keith 1977, Alberta Recreation parks and Wildlife 1978). There were scattered herds on the four to six major bench areas in any one winter (Fig. 3.18). Numbers of elk observed during these surveys and during the 1977-78 surveys are shown in Table 3.15, although these figures are not reliable due to the census method (i.e. fixed wing aircraft on one or two passes) (Gudmonson 1975 a and b).

However, the 1977-78 aerial surveys showed a somewhat different pattern of distribution. The great majority of the elk (about 86% of the total elk sightings for the two surveys) were congregated on a northeast area of land inside and outside the park (Fig. 3.18).

Snow depth measurements taken on areas not utilized by elk during the 1977-78 winter are shown in Figs. 3.19. Snow depths averaged 25 cm on the open bench areas, 56 cm in forested areas, 41 cm on lowlying open areas and 2 cm on lowlying knoll tops or ridgetops. The snow crust on these open bench areas could support an average of 133 g/cm^2. However, snow depth on the major wintering bench area (Fig. 3.21) only averaged 5 cm and there was no crusting. The

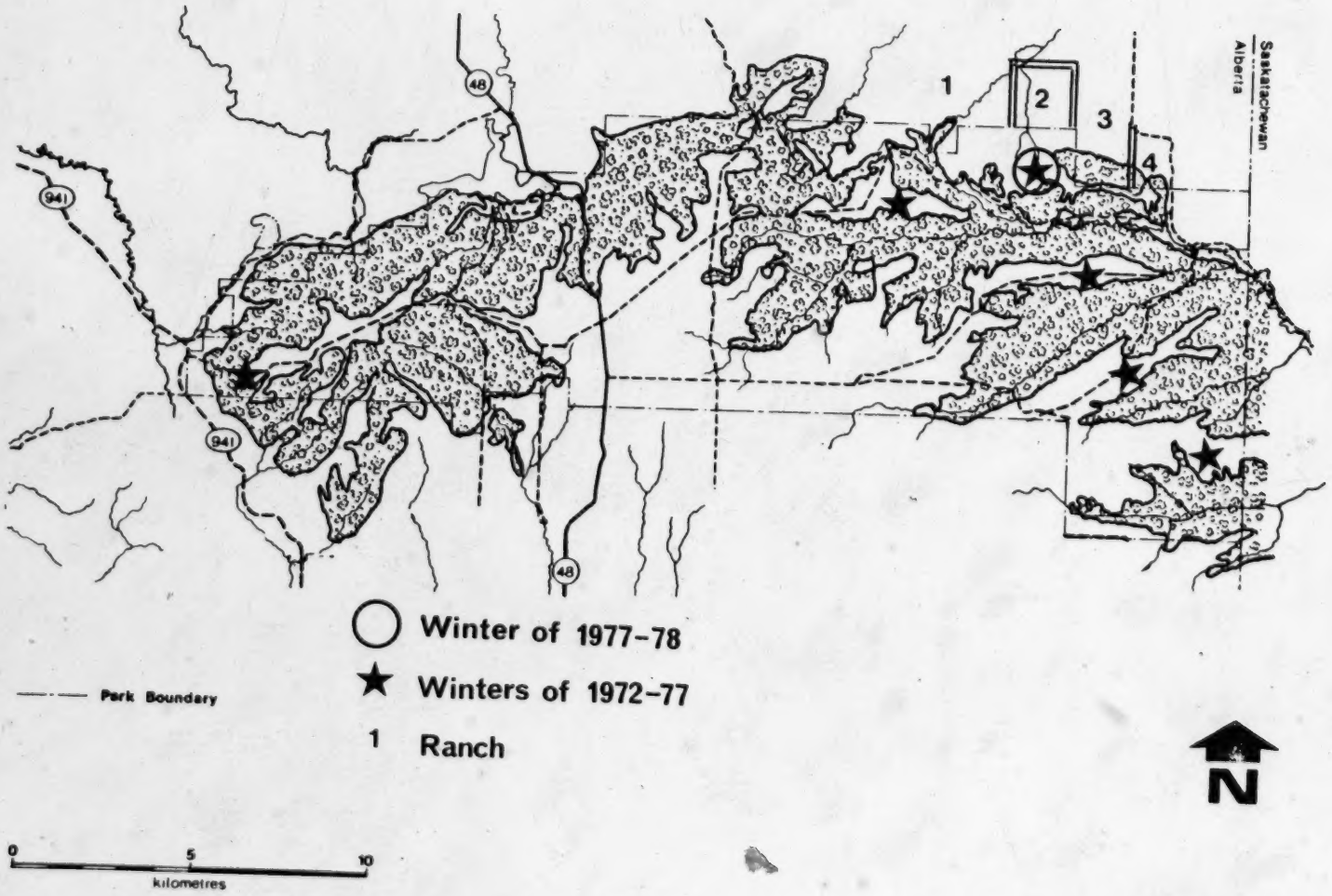

Figure 3.18 Map of the park showing locations of wintering elk herds in the winters of 1972 to 1978.

Table 3.15 Numbers of elk counted in Cypress Hills Provincial Park based on aerial surveys, 1972-73 to 1977-78.

YEAR	NO.OF ELK
1972-73[1]	221
1973-74[2]	180
1974-75[3]	250
1975-76[4]	96
1976-77[5]	250
1977-78[6]	487

1 Barrett 1972b.

2 Gudmonson 1973.

3 Gudmonson 1975b.

4 ibid 1975c.

5 Keith 1977.

6 Alberta Recreation Parks and Wildlife 1978.

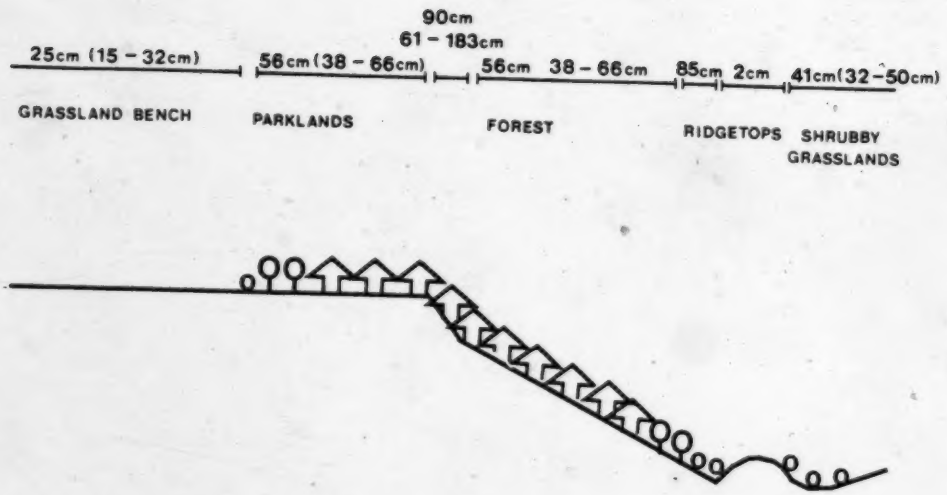

Figure 3.19 Snow depths on areas not utilized by elk during the 1977/78 winter.

Figure 3.20 Snow depths on areas not used by elk in 1977/78 winter.

Figure 3.21 Snow depths on areas used by elk in 1977/78 winter.

photographs in Figs. 3.20 and 3.21 show the difference in these two areas.

This major wintering area is show in Fig. 3.22. Much of the western and northern flanks of this bench, unlike almost all other bench areas in the park, are devoid of trees making the bench much more exposed to prevailing westerly and northerly winds. This results in a relatively snow-free surface even during winters of heavy snowfall.

The locations of the transects to determine the extent of the herd's winter range, both inside and outside the park for the 1977-78 winter and for the previous few winters are shown in Fig. 3.23.

In the 1977-78 winter, of the four areas receiving the heaviest elk use, two were inside the park and one was outside. However, in the previous winters, all four major areas were within the park (Figs. 3.24 and 3.25). In the 1977-78 winter, 33% of the elk pellets in this entire range were found outside the park boundary on 62% of the winter range area, while in the previous winters 19% of the pellets were found outside the park(Table 3.16). Of the pellet groups found outside the park, 75% were found within 1.2 km of the boundary in the 1977-78 winter. 90% of the previous winter's pellets were found within 1.2 km of the park boundary. Further, 30% of the 1977-78 winter pellets were found beyond 0.8 km from the boundary, compared to only 20% in the 1976-77 winter.

Figure 3.22 Aerial view of bench area used by wintering elk in 1977/78.

Figure 3.23 Pellet transects for winter range and movement of elk.

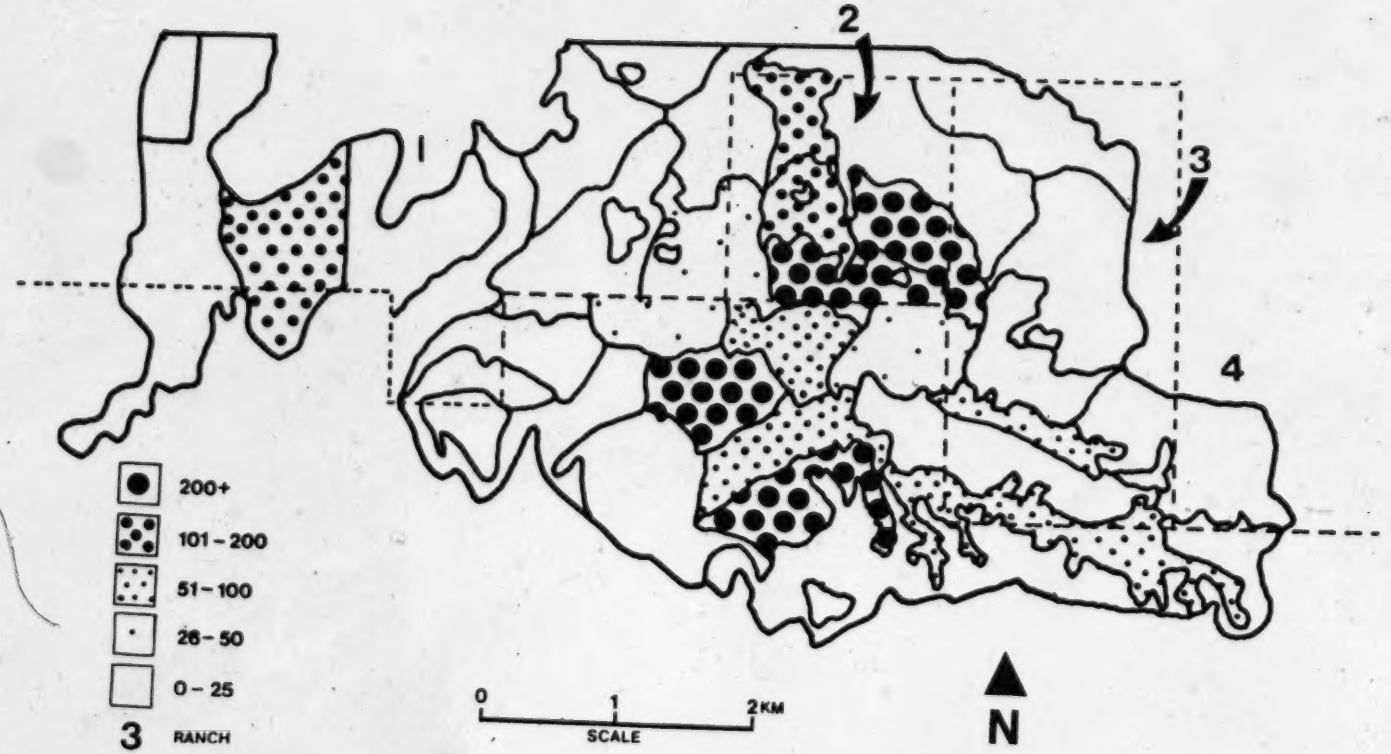

Figure 3.24 Extent of elk winter range and areas of concentration in 1977/78 winter (pellet groupings/ ha).

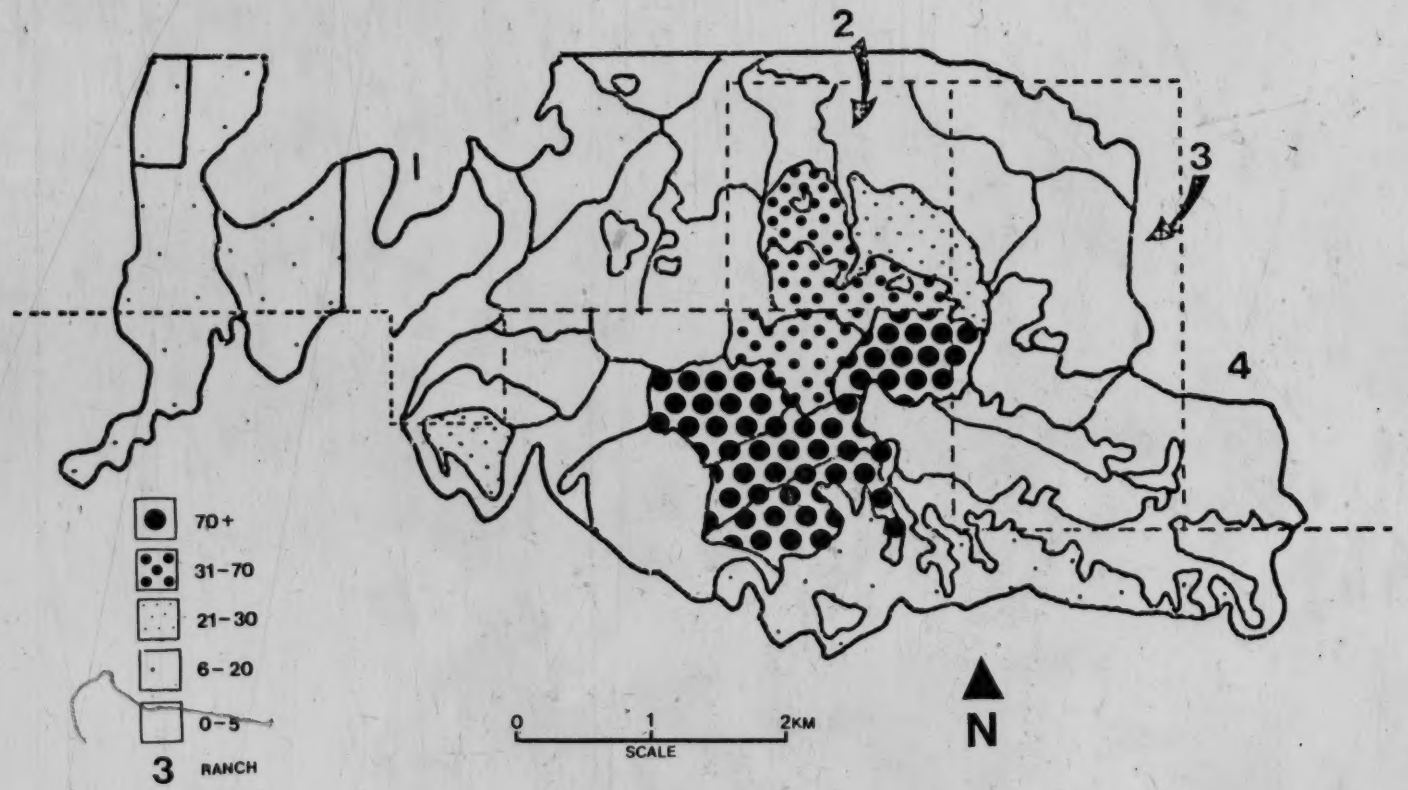

Figure 3.25 Extent of elk winter range and areas of concentration in 1976/77 winter (pellet groupings/ ha).

Table 3.16 Distribution of elk pellets in major wintering area inside and outside the Park in winters of 1976-77 and 1977-78.

Area	1976-77 WINTER			1977-78 WINTER		
	Aerial extent of elk herd (hectares)	Pellets per hectare	% of Pellets (n-67,143)	Aerial extent of elk herd (hectares)	Pellets per hectare	% of Pellets (n=130,961)
Ranch 1	481	5	3	623	13	6
2	217	20	6	259	99	20
3	374	15	8	433	21	7
4	68	10	1	68	16	1
Total Outside Park	1140	11	19	1383	31	33
Total Inside Park	702	78	81	932	94	67

Taken together, this evidence strongly implies that a much greater proportion of the elk spent more time outside the park in the 1977-78 winter than in previous winters.

3.44 Effects of Human Disturbance on Elk Habitat Selection

Fig. 3.26 shows the location of the fourteen trails located in coulees at various distances from a major road in the park. The furthest trail is 2.1 km from the road.

Although insufficient data were collected to perform tests of significance, Fig. 3.27 indicates the cumulative percentage of tracks counted on these trails at various distances from traffic on weekends (Saturday and Sunday) and weekdays (Monday to Friday) for two weeks, one each in July of 1977 and 1978. Weekends have a fewer relative number of tracks than weekdays until a distance of approximately 1.4 km from the road. At this point, the cumulative percentage of tracks is equivalent for the two periods. It is perhaps at this approximate distance and beyond that elk are not affected by the heavier weekend tourist traffic.

Figre 3.26 Location of fourteen elk trails for human disturbance study.

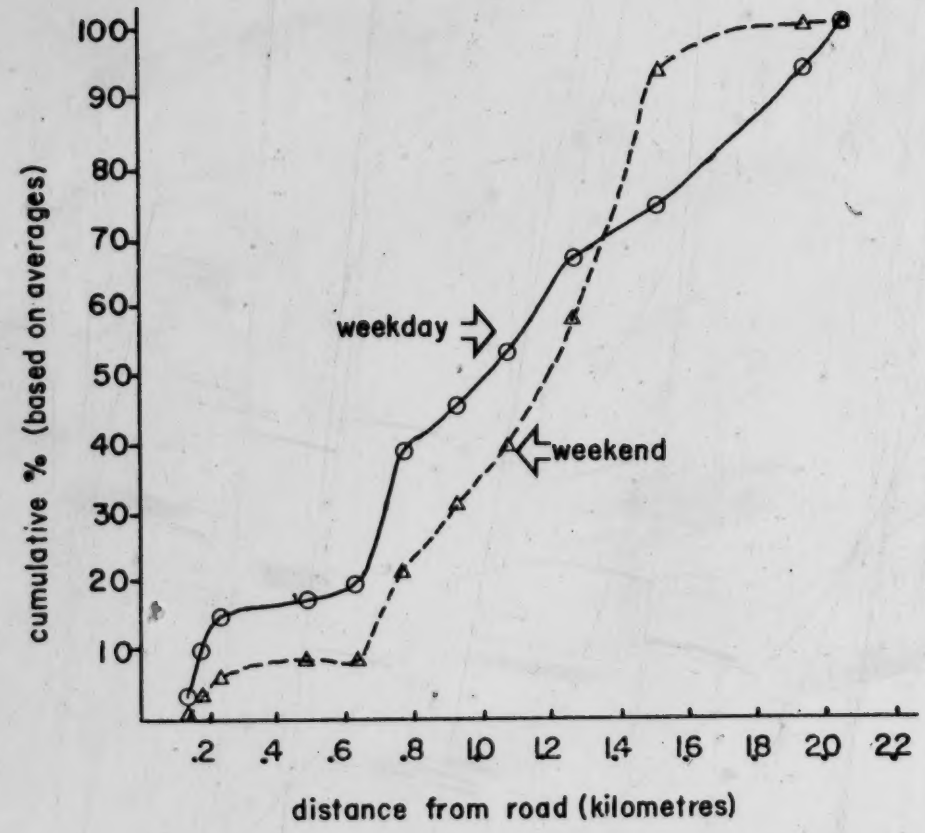

Figure 3.27 Cumulative percentage of elk trails counted on weekends versus weekdays.

3.5 Discussion

Fall-winter elk preference for certain environmental variables are only somewhat similar to a model used in a study of resource partitioning in eastern British Columbia (Hudson 1977). In that study Festuca spp., Shepherdia spp., and a mixture of vegetation structures were all positively correlated with elk presence while Stipa spp., Amelanchier alnifolia, Populus spp., were all negatively correlated. All of these responses were identical to those found in this study. Komberac (1976) also observed more ubiquitous distribution on slopes greater than 10° in the spring (and probably summer season) and a preference for southerly exposures in all seasons.

In terms of gross habitat preferences, Cairns (1976) found that elk preferred grassland habitats more in winter than in summer in Elk Island National park, Alberta. This preference was identical to that found in this study. Komberac (1976) observed increased spring use of pine-juniper forest over winter use. This compares favorably with the increased spring preference by elk for coniferous forests in the Hills. Gordon (1968) and Eustace (1967) both noted increased summer use of forested habitats and increased winter use of grassland habitats. This was also the case in this study. Overall distributions were pervasive

in summer; in winter there appearred to be more clearcut preferences and avoidances of certain habitat types. This also is supported on a more micro-scale by the higher degree of selectivity values in fall-winter.

Leege and Hickey (1977) found that elk moved out of areas where snow depth exceeded 46 - 61 cm, even at the expense of leaving better forage behind. Telfer and Kelsall (1971) found that elk were severely restricted when snow depths exceeded 51 - 64 cm. Beall (1974) found that elk occupied areas with less than 46 cm of snow. The 56 cm forest snow depth in this study would discourage entry of elk into much of the forested habitats for either cover or browse. The crusting on the open benches would greatly restrict forage availability. The lowlying bare ridgetops had very little snow on them but in general,were relatively inaccessible to elk, being mostly surrounded by great snow depths. Elk would most probably not favour these types of areas but would be attracted by the less severe conditions of shallow snow depth and little crusting on the major wintering area.

It is difficult to establish whether habitat utilization of the elk is determined largely by the presence of a food supply (see Arnold 1964, Bell 1971, Ferrar and Walker 1974, and Jarman 1974) or whether cover played a dominant role. Beall (1975) found that elk have very strong associations with cover types and rather weak associations

with food types in winter. Superficially, eta² values of the MCA models indicate that food characteristics of habitat contribute much to explaining the variance in pellet group distributions in all seasons. However, beta² values indicate that after adjusting for the effects of other environmental features, cover constituents increased in importance. The movement of elk in severe winters from areas of deep and/or crusted snows to areas in which more forage is available clearly indicates the importance of food parameters in habitat selection. However, the movement in these situations is to areas where there is still sufficient proximate cover, instead of movement to areas far from shelter (see Section 3.432).

It appears from the MCA beta² statistics for cattle that forage considerations play a more important role in determination of habitat selection in the summer period. Komberac (1976) noted that cattle highly preferred grassland over forested habitats, slopes of 0 - 10°, level aspects or southern or eastern exposures, all features found to be preferred in this study. Blood (1966), Eustace (1967) Gordon (1968) also noted cattle preference for grassland habitats, using adjacent forested areas mainly for shelter and some forage consumption. The introduction of many new individuals annually to the study areas compounds the complexity of appropriate interpretation of preferences. Whereas individual elk have often had more seasons and more years to

establish preferred regions, habitat types and environmental features, the new cattle individuals may take a certain amount of adjustment time each year to locate water supplies and areas of dense cover of preferred forage. The restriction of cattle within fenced areas would also complicate the interpretation of this modelling technique. It would appear, however, that forage characteristics of the habitat played a more important role in habitat selection than shelter considerations.

The generalized R^2 values of the MCA models compare favourably with similar models used in other studies (Hudson 1977, Salter 1978) and are a powerful tool in explaining distributions. However, limitations of the technique (such as insensitivity to interaction effects, Andrews et al. 1973) necessitated the elimination of potentially relevant variables and the *a priori* determination of discrete categories when the boundaries on those categories are most likely artificial. These restrictions indicate that even seemingly low multiple correlation coefficients may indicate preferences and avoidance to a degree. There is also difficulty, however, in determining what is present in the environment that the animal responds to (Moen 1973). The positive correlation of cattle presence with *Calamagrostis* spp. may only reflect an actual response to other features with which *Calamagrostis* spp. is positively associated and these may not have been examined and sorted by the THAID

program.

Chapter 4: FORAGE AND FEEDING

FORAGE AND FEEDING

4.1 Introduction

In general, elk appear to prefer grasses but the foods eaten and their proportion varies with the habitats occupied and with the season. In fact, Murie (1951) considered that the one thing that is characteristic of the food habits of elk is their extreme variability. Diets range from a year-round consumption of grass with only traces of other plants represented (Cowan 1947, Murie 1951, Morris and Schwartz 1957) to a mixed diet (Blood 1966, Cairns 1976) to a predominantly browse diet (Gaffney 1941, Rognurd and Jansen 1971). When there are seasonal shifts in forage classes consumed, it is in the winter period that browse is most heavily utilized (Boyd 1970, Cairns 1976) although this is not consistent (Young and Robinnette 1939). Forbs are often more important dietary constituents than graminoids (Stevens 1966, Martinka 1969). For the Cypress Hills area Keith (1977) reported the rumen contents of 13 elk taken in late October/early November. Graminoids constituted 66%, forbs 17%, and trees and shrubs 17% of the rumens. Keith also indicated that grasses were important in the winter diet.

Cattle are known to prefer grass and grass-like plants but will readily eat forbs and browse (Blood 1966, Eustace

1967, Mackie 1970, Hansen and Reid 1975, Hubbard and Hansen 1976, Hansen et al 1977, Olsen and Hansen 1977, Salter 1978). Clarke and Tisdale (1945) have reported which plants cattle readily consume in the fescue range type (as in the Cypress Hills) and these include: western porcupine grass and green needle grass (Stipa spartea var. curtiseta and S. viridula), northern and awned wheatgrasses (Agropyron dasystachyum and A. subsecundum), rough fescue (Festuca scabrella), brome grasses (Bromus spp.), Indian rice grass (Oryzopsis hymenoides), sand dropseed (Sporobolus cryptandrus), oat grasses (Danthonia spp.) and willows (Salix spp.).

Information on food habits of elk and cattle on similar ranges is included in Smith (1961), Blood (1966), Stevens (1966), Eustace (1967), Gordon (1968), Mackie (1970), Hansen and Reid (1975), Komberac (1976), Hansen et al (1977), Salter (1978) and others. Overlaps of elk and cattle diets ranged from 42% (Hansen and Reid 1975) in a Southern Colorado study to 46% (Hansen et al 1977) in a northwestern Colorado study, to 35% in Southwestern Montana (Eustace 1967), 47% in west-central Montana (Gordon 1968), 43% in north central Montana (Komberac 1976); 34% for spring elk and summer cattle and 45% for late winter elk, summer cattle in western Alberta (Salter 1978).

Determination of the effects that elk and cattle have on their food supply and the ability of that food supply to

support various population levels necessitated the inventory of standing crop, production and utilization of their food species. The two major classes of forage are herbs and browse. Even though forbs are generally considered to be the major dietary constituents of both elk and cattle, the catholic dietary characteristics of elk and the apparent overbrowsed condition of many shrub species throughout the study area made it appropriate to obtain information on browse as well as forb productivity, standing crop and utilization.

4.2 Methods

4.21 Diet Composition

Diet composition was determined by identification of plant fragments in the feces. Fifty samples of fresh elk feces were each collected during the middle two weeks of May (for a spring sample), June, July, August (for summer samples). A composite fall sample and winter sample were also collected. Fifty samples of fresh cattle feces were also collected during the middle two weeks of June, July, August and September. Each sample consisted of 1 - 2 g. All samples were obtained within the eastern half of the park from scattered locations in both grassland and forest habitats. All samples were air dried in order to limit bacterial and fungal action.

In preparation for analyses the samples were combined on an equal dry weight basis into composite summer monthly samples for elk and cattle and fall, winter and spring samples for elk for a total of 10 composite samples. The composite samples were oven-dried at 85°C for 48 hr. then ground in a Wiley mill using a 20 mesh screen. Approximately 10 g of each thoroughly mixed composite sample were sent to the Composition Analysis Laboratory, Colorado State University, for analysis at 240 microscopic fields per sample (Hansen et al. n.d., Sparks and Malechek 1968). This technique provides results which approximate the relative dry weights of food categories in the diet (Sparks and Malechek 1968, Hansen et al. 1973, Todd and Hansen 1973, Dearden et al. 1973).

4.22 Browse and Forb Productivity, Standing Crop and Utilization

Numbers of various browse species produced and utilized were determined using the point centered quarter method (Cottam and Curtis 1956). Twelve transects, each consisting of approximately 20 sampling points, were investigated. Determination of twig weight-diameter relationships were made of eight shrub species to determine the production and utilization of the average twig following the methodologies of Telfer (1968, 1969, 1972 and 1974).

Grass and herb productivity, standing crop and

utilization were determined with the use of 1 m diameter wire exclosure cones (4 cm and 8 cm mesh) and adjacent unprotected plots. In 1977, 18 cones were established before cattle grazing began (i.e. before May 20) (see Fig. 3.1 for locations). An adjacent plot of apparent similarity, to that within each cone, with regard to plant composition and abundance was chosen at that time between 5 and 20 m from the cone. The vegetation within the cone and on the adjacent plot was clipped on October 12, 1977, after cattle had been removed from the park. Clipping height was approximately 2 - 3 cm and all plant material above this height, including old litter, was collected. This gave information on standing crop and utilization. In 1978, 43 cones were set up (of which 18 corresponded to the same locations in 1977) (see Fig. 3.1 for locations), again before cattle grazing commenced. All plant material above 2 - 3 cm was removed at this time. Adjacent plots were chosen and all plant material above 2 - 3 cm was removed both from this plot and from the exclosure core. Clipping again occurred after cattle grazing was completed (mid-October). This gave information on productivity and utilization for 1978.

4.3 Diet Composition

4.31 Cattle

A total of 28 plant categories (species and species groups) were identified in the cattle feces collected in the grazing season of 1977-78 (the June sample may have contained some feces deposited in late May). Grasses were substantially the most important dietary constituent, comprising about 77% of the diet, with a much reduced percentage in June (63%) and a much greater percentage in September (89%). Festuca spp. (likely scabrella) was by far the most heavily utilized food item, contributing 63% of the total diet, the least use being in June. Danthonia spp. (likely intermedia) was the second most important grass (at 12% of the total diet) but its use varied substantially from a low of 4% in June to 18% in August. No other grass contributed much to the diet with only Stipa spp. contributing 1.0% to the total diet and Poa spp. only 2.5% in the June sampling. Sedges received their greatest consumption in June (31%) but this consumption decreased throughout the summer until a low of 9% was used in September for an average seasonal consumption of 19% (Table 4.1). Grasses, sedges and rushes contributed over 94% of total diet in any one month.

Table 4.1 . Percentages of plant fragments in samples of cattle feces, 1977-78.

Species	June	July	August	September	Total
Grasses					
Agropyron spp.	0.2		0.2		0.1
Bouteloua gracilis	0.4	0.2			0.2
Bromus spp.	0.2	0.2	0.4		0.2
Calamagrostis spp.			0.4		0.1
Danthonia spp.	4.0	11.0	17.6	14.0	11.6
Festuca spp.	54.3	66.6	58.2	72.5	62.9
Koeleria-cristata spp.				0.2	0.1
Muhlenbergia spp.			0.2	0.2	0.1
Poa spp.	2.5	0.2	0.2	0.4	0.8
Sitanion-type spp.				0.4	0.1
Stipa spp.	0.9	0.2	1.2	1.7	1.0
Unknown grass	0.2				0.1
Total grasses	62.7	78.4	78.3	89.3	77.2
Sedges & Rushes					
Carex spp.	30.9	18.03	17.6	9.4	19.0
Eleochaus spp.	0.7				0.2
Juncus spp.	0.7		0.4		0.3
Total Sedges & Rushes	32.2	18.03	18.0	9.4	19.4
Total graminoids	94.9	96.4	96.3	98.7	96.7
Forbs					
Astragalus spp.	0.4				0.1
Compositae spp.	0.7	0.6			0.3
Cryptantha spp.		0.2			0.1
Lupinus spp.		0.2	0.4	0.2	0.2
Phlox spp.		0.2			0.1
Potentilla-Geum spp.	2.0		2.0	0.6	1.1
Unknown forb	0.7		.2		0.2
Total Forbs	3.8	1.1	2.6	0.8	2.1
Browse					
Pinus contorta	0.7		0.4	0.2	0.3
Populus-Amelanchier		1.0			0.2
Rosa spp.	0.4				0.1
Salix spp.		1.5	0.6	0.4	0.6
Shepherdia-Eleagnus spp.			0.2		0.1
Total Browse	1.1	3.6	1.2	0.6	1.3
Miscellaneous					
Equisetum	0.2				0.1

Both forbs and browse received negligible use. Of the forbs only the Potentilla - Geum group received over 1% use in the total seasonal diet or in any monthly diet. Forbs were utilized the most in June. No one browse species group received over 1% use in the total seasonal diet but Salix spp. was the heaviest shrub species used and especially so in July. Ferulus - Arelanchier was the only other browse species that received 1% use (in July).

4.32 Elk

A total of 32 plant categories (species and species groups) were identified in elk feces from 1977 and 1978 collections (Table 4.2). Grasses were the most important constituent, comprising about 74% on an annual basis, but there was great seasonal variation. Grasses contributed almost 33.3% of the total diet in summer and 93% or greater in winter and spring. August had the lowest use at 15%. Festuca spp. (likely scabrella) was by far the most heavily utilized food item, constituting over 70% of the annual diet, with a seasonal decrease in utilization in summer (especially August). No other grass constituted more than a mean of 1.7% of the annual diet although Danthonia spp. (likely intermedia) contributed 9.6% of the total diet in July. On an annual basis, sedges were not important, contributing only 3.4% of the diet, but use was greatest in summer (11.8% in July) and least in winter (1.1%). Juncus

Table 4.2 . Percentages of plant fragments in samples of elk feces, 1977-78.

Species	Fall Winter	Spring Summer	Spring	Summer	June	July	August	September	Winter	Total
Grasses										
Agropyron	0.3	1.1						0.2	0.5	0.3
Bouteloua gracilis	0.1								0.1	0.1
Bromus	1.0			1.4	1.2	1.9	1.1	1.3	0.8	1.0
Calamagrostis	0.7							1.3		0.1
Danthonia	0.4	3.8		5.1	3.4	9.6	2.3	0.7	0.1	1.7
Festuca	83.6	41.3	89.6	25.1	22.3	41.8	10.8	73.2	94.0	70.8
Koeleria cristata	0.3	0.2	0.2	0.2	0.7				0.6	0.4
Oryzopsis		0.1	0.2							<0.1
Poa	0.4	0.6	0.4	0.7	1.7		0.3	0.7	0.2	0.4
Stipa	0.8	1.2	2.6	0.8	0.9	0.8	0.6	0.7	1.4	1.2
Unknown grass	.2							0.3		< .1
Total Grasses	87.7	48.2	93.0	33.3	30.6	54.1	15.1	77.7	97.8	74.3
Sedges & Rushes										
Carex	1.3	6.9	4.3	7.7	9.4	11.8	2.0	1.5	1.1	3.4
Juncus	.1	0.1		0.2	0.2	0.3		0.2		0.1
Total Sedges & Rushes	1.4	7.0	4.3	7.9	0.6	12.1	2.0	1.7	1.1	3.5
Total graminoids	89.1	55.2	97.3	41.2	40.2	66.2	17.1	79.4	98.9	77.8
Forbs										
Artemesia	0.1							0.2	0.1	0.1
Astragalus	0.1	0.1		0.2		0.3	0.3	0.2		0.1
Atriplex	.1							0.2		0.2
Compositae	0.2	0.2	0.1	0.2		0.3	0.3	0.2	0.2	0.2
Lupinus	0.6	0.6		0.9			2.6	1.0	0.1	0.4
Phlox	0.3							0.3	0.2	0.1
Potentilla-Geum		10.7	2.0	13.7	29.1	10.2	1.7			4.3
Unknown Forb	0.1	0.1		0.1		0.3			0.1	0.1
Total Forbs	0.8	11.8	2.1	15.0	29.1	11.0	4.8	1.9	0.8	5.5
Browse										
Amelanchier alnifolia	0.1	0.1		0.2	0.5				0.1	0.1
Picea	0.1								0.1	0.1
Pinus	0.2	1.1		1.5		1.1	3.4	0.3	0.1	0.6
Populus-Amelanchier	0.2	4.1		5.5		3.3	14.2	0.3		1.7
Prunus		0.1		0.1	0.2					<0.1
Rosa	0.4	3.2		4.3	6.43	3.9	2.6	0.8		1.4
Rubus	1.9	3.9		5.2			15.6	3.7		1.9
Salix	5.9	7.5	0.1	9.9	4.9	5.4	19.6	11.7		4.2
Shepherdia-Eleagnus	.8	13.0	0.4	17.2	18.7	10.2	22.6	1.1		5.3
Symphoricarpos	.3	< .1	0.1					0.7		0.1
Total Browse	9.5	33.0	.6	43.8	30.2	22.8	77.8	18.7	0.4	15.3
Miscellaneous										
Equisetum		0.1		0.1			0.3			<0.1

spp. contributed less than one percent of any sample period.

Forbs were of only slightly more importance than sedges but this varied tremendously throughout the year. They were much more important in early summer (29.1% in June) and decreased steadily in importance throughout the rest of summer and into fall and winter (where they contributed only 0.8% of the total diet). The Potentilla - Geum group (this could also include some Potentilla fruticosa) contributed more than 10 times the dietary percentage than any other forb species or forb species group on an annual basis. But this also varied greatly as this group was absent in the diet in fall-winter and contributed as much as 29.1% of the total diet in early summer (June). Lupinus spp. (likely argentea) was the second most important forb utilized and was most heavily utilized during August (2.6%).

Browse was a highly variable dietary constituent, ranging from 0.4% in winter and 0.6% in spring to 77.8% in August, with an average annual use of 15.3%. During summer, however, use averaged 43.6%. Those species or species groups contributing over 1% of the annual diet were Shepherdia Eleagnus (canadensis and commutata, respectively) Salix spp., Rubus spp., Populus - Amelanchier and Rosa spp. (in descending order of use). Pinus contorta contributed over 1% in July and August.

4.4 Forage Standing Crop, Productivity and Utilization

4.41 Browse Standing Crop, Productivity and Utilization

Production refers only to twig production and not leaf production. The data therefore, are relevant for the winter period. Twig production in the park was estimated to be 56,034 kg during 1977 (Table 4.3). In terms of canopy cover, the more open the canopy cover, the greater the number of twigs and consequent production. For example, very open areas (type 2, 3, 4, Table 4.3) had 34,356 twigs per hectare for a total production of 13,884 kg and mixed forest (type 6, Table 4.3) had 10,971 twigs per hectare for a total production of 14,250 kg. Coniferous forest (type 7) had 9,682 twigs per hectare and produced 6,014 kg while closed canopy conifer and dense pine had only 1,405 twigs per hectare with a production of 1,709 kg (although no production data were collected for *Pinus contorta*, *Potentilla fruticosa*, *Prunus* spp. or *Viburnum* spp.).

The six most plentiful shrub species were, in descending order, *Populus* spp. (both *tremuloides* and *balsamifera*), *Potentilla fruticosa*, *Rosa* spp. (*woodsia*, *arkansana* and *acicularis*), *Shepherdia canadensis*, *Symphoricarpos* spp. (*occidentalis* and *albus*) and *Cornus*

Table 4.3. 1977 Production and Utilization values for various shrub species in canopy cover types.[1]

Species	Average Twig[3] Production (g)	Average Twig[3] Utilization (g)	Twigs per Hectare U[4]	Twigs per Hectare B[5]	Twigs per Hectare T[6]	% Twigs Browsed	1a[2] = 2513 ha Production kg/ha	1a[2] = 2513 ha Utilization kg.ha	Total Production (kg x 10^3)	Total Utilization (kg x 10^3)	% Utilization
1. Amelanchier alnifolia	.44	.22	137	273	410	66.6	180	60	452	151	33.4
2. Cornus stolonifera	.94	.51									
3. Elaegnus commutata	.40	.27	89	58	147	39.5	59	16	148	40	27.0
4. Pinus contorta	nd[7]	nd									
5. Populus spp.	.55	.21	6	37	43	86.0	24	8	60	20	33.3
6. Potentilla fru ticosa	nd	nd	89	12	101	11.9	nd	nd	nd	nd	nd
7. Prunus spp.	nd	nd	76	75	151	49.7	nd	nd	nd	nd	nd
8. Rosa spp.	.20	.08	242	189	431	43.9	86	15	216	38	17.6
9. Salix spp.	1.50	.56									
10. Shepherdia canadensis	.34	.13									
11. Symphoricarpos spp.	.65	.18	183	47	230	20.4	150	8	377	20	5.3
12. Viburnum spp.	nd	nd									
TOTALS			822	691	1513	45.7	499	107	1253	269	21.5

1 See Appendix B for detailed calculations and methodology.

2 Refers to canopy cover types (Table 3.2). (1a here refers to scattered grassland non-bench)

3 Is the weighted average production and utilization of the average twig for that species.

4 U = Unbrowsed

5 B = Browsed

6 T = Total browsed and unbrowsed

7 nd = no data.

2, 3, 4 = 1 2 2 1 ha (Transect 0)

Species	Twigs per Hectare U	B	T	% Twigs Browsed	Production g/ha	Utilization g/ha	Total Production (kg)	Total Utilization (kg)	% Utilization
1.									
2.									
3.									
4.	350	44	394	11.2	nd	nd	nd	nd	nd
5.	15342	5333	20675	25.8	11371	1112	13884	1358	9.8
6.	13200	87	13287	0.7	nd	nd	nd	nd	nd
7.									
8.									
9.									
10.									
11.									
12.									
TOTALS	28892	5464	34356	15.9	11371	1112	13884	1358	9.8

5 = 1 0 8 1 ha (Transect L)

Species	Twigs per Hectare U	B	T	% Twigs Browsed	Production g/ha	Utilization g/ha	Total Production (kg)	Total Utilization (kg)	% Utilization
1.	204	1471	1675	87.8	737	324	796	350	44.0
2.	2083	6373	8456	75.4	8332	3250	9007	3513	39.0
3.									
4.									
5.	2083	4861	6944	70.0	3120	1021	3373	1104	32.7
6.									
7.	531	940	1471	63.9	nd	nd	nd	nd	nd
8.	490	286	776	36.9	155	23	168	25	14.9
9.	286	531	817	65.0	1226	297	1325	321	24.2
10.	123	286	409	69.9	139	37	150	40	26.7
11.	5147	694	5841	11.9	3797	125	4105	135	3.3
12.									
TOTALS	10947	15442	26389	58.5	17506	5077	18924	5488	29.0

6 = 3389 ha (Transects W, I, P, A)

Species	Twigs per Hectare U	B	T	% Twigs Browsed	Production g/ha	Utilization g/ha	Total Production (kg)	Total Utilization (kg)	% Utilization
1.	840	441	1281	34.4	564	97	1911	329	17.2
2.	123	147	270	54.4	254	75	861	254	29.5
3.									
4.	270	18	288	6.3	nd	nd			
5.	2027	1434	3460	41.4	1903	301	6449	1020	15.8
6.	981	0	981	0	nd	nd			
7.	88	94	182	51.6	nd	nd	nd	nd	nd
8.	1416	905	2321	39.0	464	72	1572	244	15.5
9.	29	0	29	0	44	0	149	0	0
10.	529	764	1293	59.1	440	99	1491	356	23.9
11.	805	18	825	2.2	536	3	1817	10	0.6
12.	41	0	41	0	nd	nd			
TOTALS	7149	3821	10971	34.8	4205	647	14250	2213	15.5

7 = 1689 ha (Transects N & E)

Species	Twigs per Hectare U	B	T	% Twigs Browsed	Production g/ha	Utilization g/ha	Total Production (kg)	Total Utilization (kg)	% Utilization
1.	340	350	792	44.2	348	77	588	130	2.2
2.									
3.									
4.	535	0	535	0	nd	nd	nd	nd	nd
5.	1708	1142	2850	40.1	1568	240	2648	405	15.3
6.	669	0	669	0	nd	nd	nd	nd	nd
7.	41	72	113	63.7	nd	nd	nd	nd	nd
8.	1008	741	1749	42.4	354	59	598	100	16.7
9.	41	134	175	76.6	263	75	444	127	28.6
10.	1718	854	2572	33.2	874	111	1476	187	12.7
11.	237	0	237	0	154	0	260	0	0
12.									
TOTALS	6297	3293	9682	33.9	3561	562	6014	949	15.8

8 & 9 = 4109 ha (Transects D & R)

Species	Twigs per Hectare U	B	T	% Twigs Browsed	Production g/ha	Utilization g/ha	Total Production (kg)	Total Utilization (kg)	% Utilization
1.	30	19	49	38.8	22	4	90	16	17.8
2.									
3.									
4.	62	0	62	0	nd	nd			
5.	325	102	427	23.9	239	21	982	86	8.8
6.	8	0	8	0	nd	nd			
7.	89	8	97	8.2	nd	nd			
8.	288	27	315	8.6	63	2	259	8	3.1
9.									
10.	183	62	245	22.8	92	8	378	33	8.7
11.									
12.	202	27	229	11.8	nd	nd			
TOTALS	1187	245	1405	17.1	416	35	1709	143	8.4

Species	Production (kg)	Utilization (kg)	TOTAL % Utilization	# Twigs (x 10^3) U	B	T	% Twigs Browsed
1.	3837	976	25.4	4109	4440	8549	48.1
2.	9868	3767	38.2	2669	7387	10056	73.5
3.	148	40	27.0	224	146	369	40.0
4.	nd	nd	nd	2501	115	2616	4.4
5.	27396	3993	14.6	32089	19067	51156	37.3
6.	nd	nd	nd	20828	136	20965	0.6
7.	nd	nd	nd	1498	1678	3176	52.8
8.	2813	415	14.8	8823	5214	14036	37.1
9.	1918	448	23.4	477	800	1277	62.6
10.	3495	616	17.6	5579	4596	10175	45.2
11.	6359	165	2.5	9152	929	10088	9.2
12.	nd	nd		969	111	1080	10.3
TOTALS	56034	10420	18.6	88918	44619	133537	50.2

stolonifera.[1] Of those species for which production data were collected, Populus spp. contributed the most to the total production (at 49%). Much less, but still substantial quantities, were produced by Cornus stolonifera, Symphoricarpos spp., Amelanchier alnifolia, Shepherdia canadensis, Rosa spp. and Salix spp.

Salix spp. and Cornus stolonifera had the highest average twig production for 1977 (1.50 and 0.94 g respectively). These two species also had the highest average utilization per twig (0.56 and 0.50 g per twig), the highest percentage of twigs browsed (62.6 and 73.5% respectively) and the highest percentage of utilized production (23.4 and 38.2% respectively). Taken together, these data suggest that these were highly preferred food items by one or more ungulate species.

The total percentage of twigs browsed was 50.2% and the total percent of utilized production was 18.6%. However, deciduous forest (type 5) had much higher percentages at 58.5% and 29% respectively. More open areas (types 2, 3, 4) and dense pine areas (types 8, 9) had the lowest utilization.

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[1] Production data for Cornus stolonifera (9,868 kg for the entire park area) were probably overestimated since the data were obtained from only one transect (transect 1) which was located in a rather moist area (see Fig. 3.1 for location). As well, Cornus stolonifera did not show up in the fecal fragment identification of any species (unless it is the "unknown bark" component for moose Table 6.5).

4.42 Forb Standing Crop, Productivity and Utilization

Standing crop in 1977 averaged 82.3 g/m² (or 50.6% of 1978) on areas that were grazed substantially (areas VP, south 1/2 and NMC, Table 4.4). The same areas in 1978 (the same cones were placed between 5 and 20 m from their 1977 spot) had a production average of 162.8 g/m².

1977 was a relatively dry year (Section 2.3). Precipitation at Medicine Hat was 302.5 mm or 45.2 mm below the 30 year average. Precipitation in 1978 was 459.2 mm or 111.5 mm above the 30 year average. 1977 had average annual temperatures only 0.2°C below the 30 year average while 1978 had 2.1°C below the 30 year average. This greatly influenced the productivity of forage resources in the park.

As a result of the low productivity in 1977, utilization was high because cattle stocking rates were 50% higher in 1977 than in 1978 (Section 3.32). As well, elk population levels were high in both years. Utilization in 1977 on areas that were grazed substantially averaged 62% while the same areas in 1978 had an average utilization of only 40%.

Standing crop in 1977 on heavily grazed areas was 42.9 g/m² (areas VP, south 1/2 and NMC) while on very lightly grazed areas was 280.3 g/m² (VP, north 1/2). The first two areas had been historically heavily grazed while VP, north 1/2, had been historically very lightly grazed.

Table 4.4 . Productivity (1978), Standing Crop (1977) and Utilization (1977 and 1978) on the open areas in Cypress Hills Provincial Park.

Area	Cone #'s	N	Productivity & Utilization in 1978 Ungrazed g/m^2	Grazed g/m^2	% Utilized	Standing Crop & Utilization in 1977 Ungrazed g/m^2	Grazed g/m^2	% Utilized	Area (ha)	Production & Utilization in 1978 Product. (kg)	Utiliza. (kg)	Standing Crop & Utilization in 1977 Product. (kg)	Utiliza. (kg)
VP[1] North 1/2	2,3,4,7,8,9,10, 12,13	9	254.6	220.3	13.3	280.3	231.0	17.6	109.8	279550	37180	307770	54170
VP South 1/2	5,6,11,14	4	173.2	83.3	51.9	117.9	29.4	75.1	61.1	105820	54920	72040	54100
RHP	20,21,22,23,24	4	249.1	186.8	25.0				65.2	162410	40600		
PP North 1/2	27,28,29	3	236.5	193.1	18.4				127.4	301300	55440		
PP South 1/2	25,26	2	212.7	163.2	23.3				56.0	119110	27750		
STP	30,40,41,42,43	5	154.1	119.0	22.8				382.4	589280	134360		
DHC	15,16,17,18,19	5	152.4	110.1	27.8	46.7	24.1	48.4	646.8	985720	274030	302060	146190
MB	34,35	2	191.7	142.8	25.5				3504.2	6717550	1712980		
VE	36,37,38	3	364.9	247.7	32.1				103.1	376210	120760		
SFL	32,33	2	150.8	142.0	5.8								
			234.6	183.8	21.7								
SG	30,31	2	317.9	225.5	29.1				2512.8	5895030	1279220		
									7568.8	15531980	3737240		
											(24.1%)		

[1]See Figure 3.1 for locations.

Productivity in 1978 averaged 202.9 g/m² on all sites - 254.6 g/m² on lightly grazed areas (VP, north 1/2); 185.4 g/m² on heavier grazed areas (VP, south 1/2; PP; STP, NMC and ME). Total production on the open grassland areas in 1978 is estimated at 15,532 x 10^3 kg.[2] Utilization for the period of May 15 to September 30 is estimated at 3,737 x 10^3 kg or 24.1% of the production. Utilization was least on south-facing slopes (5.8%), the north 1/2 of VP (13.3%) and the north 1/2 of PP (18.4%). Utilization percentage was greatest on the south 1/2 of VP (although data only represent one exclosure zone since the other zones were disturbed - see Appendix E).

4.5 Discussion

Diet composition of elk and cattle in Cypress Hills Provincial Park is similar to that found in other areas. Blood (1966) also found that graminoid consumption by elk is greater in autumn, winter and spring, than in summer; that forb consumption is least in this period and that browse consumption is lowest during spring. Mackie (1970) also found that browse and forbs were preferred by elk in summer more than in winter during which time grasses were the main

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[2] This figure is assumed to be high since Potentilla fruticosa were avoided when placing cones due to the prohibitive size of this shrub for the size of the cone. Therefore estimates could reasonably be reduced by perhaps 10% due to the plentiful and ubiquitous distribution of shrubby cinquefoil (Brietung 1954, Klumph 1978).

dietary constituent (also see Eustace 1967). In Riding Mountain National park, cattle use of graminoids and forbs was very high (>96%; in this study >98%) and browse consumption was low (<4%; in this study <2%). Browse consumption by cattle in Mackie's (1970) study was also very low (<1%).

There are very few studies of the effects of various levels of utilization on browse species. Lay (1965) studied several species, none of which were the same as those found in this study area. Nevertheless, he found that different species showed a high variation in their resistance to use. The level of utilization at which some species can maintain production is less than 25%. For others, something over 50% may be acceptable. He felt that the optimum level for most species is probably closest to 25%. Overall utilization by weight of the eight shrub species examined in this study was 18.6%. However, the overall percentage of twigs browsed was 50.2%. Often browsed twigs incur die-back to the point of the previous growing season. As well, certain species had utilization over the 25% level - Amelanchier alnifolia, Cornus stolonifera and Eleagnus commutata. Other species were overutilized in certain cover types - Populus spp. in scattered grassland and deciduous forest types, Shepherdia canadensis in deciduous forest and Salix spp. in coniferous forest. This high use of Shepherdia canadensis and Eleagnus commutata in certain locations would probably indicate that

the palatable species (i.e. Salix spp., Cornus stolonifera, Ribes spp., etc.) were under considerable browsing stress. The only shrub species studied that were not overutilized were Rosa spp. and Symphoricarpos spp. The total production and utilization values are considered much lower than actual although comparative values (utilization percentages, relative production and utilization on various species, etc.) are corsidered relatively accurate. The twig-count methodology and its application in this study is considered responsible for these low values. Regardless, generalizations on total production may be somewhat meaningless, as annual or intra-seasonal (winter especially) differences in snow depths will substantially affect the amount of available browse (twigs) and it may be availability and not annual production variations that is more important to winter browsing herbivores.

Proper utilization of forbs in relation to production is also difficult to assess (Heady 1975) and may depend on such factors as annual variation in productivity due to climatic changes (Smoliak 1956, found variations of 100-925 kg/ha between 1930 and 1953 in the short grass plains of southern Alberta; productivity in the study area was 308.4 kg/ha in 1968 and 183.3 kg/ha in 1974 - see Section 2.52); season of intensive grazing (Stoddard 1946) and type of forb grazed (for example, Agropyron smithii should be grazed to a stubble height of 7.5 - 10 cm and Koeleria cristata to a

height of 5 cm (parker and Glendening 1942)); etc. Klumph (1978) has considered some of these factors and others to derive a carrying capacity figure of 5,500 AUM's annually on the bench areas of the park (all areas on Table 4.4 except SFL and SG).

Chapter 5: RESOURCE PARTITIONING - ELK AND CATTLE

RESOURCE PARTITIONING - ELK AND CATTLE

5.1 Introduction

The analysis of resource partitioning by two or more ungulates requires consideration of the niche dimensions of habitat (space) food and time (Schoener 1974, Hudson 1977). Traditionally, this has often been accomplished by describing seasonal overlaps in habitat utilization and food (eg. Stevens 1966, Allen 1968, Constan 1972). Indices descriptive of spatial and habitat overlap or interspecific association have received increasingly important use (Cole 1948, Hurlbert 1968, Telfer 1972, Irwin 1975, Anthony and Smith 1977, Hurlbert 1978). Recently, attempts have been made to evaluate resource division on the basis of vectorial response to habitat and functional interactions of coexisting species (Ferrar and Walker 1974, Hudson 1976, Hudson et al. 1976, Hudson 1977).

In this study information on resource partitioning by elk and cattle was obtained by consideration of the niche dimensions of habitat (space), food and time. These dimensions were considered in terms of indices of spatial, habitat and food overlaps on a seasonal basis.

5.2 Methods

Resource partitioning on the basis of space and habitat was evaluated using indices of spatial overlap, coincidence, association, coefficient of site association, interspecific crowding and habitat overlap. Coincidence indices (Dice 1945) provide measures of how much of the combined area used by the two species sustains mutual use. association indices (Dice 1945) indicate the direction and degree of site overlap. Coefficient of site association (C8) (Hurlbert 1969) provides a frequency independent measure of association. Interspecific crowding (Hurlbert's (1978) equation 14) is the mean density of individuals (fecal groups) of one species confronting the other species. Spatial overlap (Hurlbert's equation 12) is the probability of interspecific encounter within the transect plots and habitat overlap (Hurlbert's equation 11) is the probability of interspecific encounter within vegetation associations (vegetation associations were chosen rather than canopy cover types because the greater number of associations allowed more refinement of the fecal group distributions)(Hurlbert 1978).

Cattle and elk diets representing various periods were compared using Kulczynski's similarity index (Oosting 1956) which indicated what percentage of a pair of diets was

identical. Spearman's rank order correlation coefficient (Seigal 1956) was also used to compare diets and indicated to what degree species were chosen in the same or opposite orders by a pair of ungulates. [3] One or both of these measures have been used in previous studies of elk and cattle diets (Hansen and Reid 1975, Hansen and Clark 1977).

Comparative indices of overlap of space, habitat, food and overall indices of niche overlap on a temporal basis were evaluated after Arthony and Smith (1977) and May (1975). Although referred to as competition coefficients by these authors, the designation in this study is niche overlap (see Chapter 1, Introduction).

The proper computation of niche overlap depends on the relationship (dependence or independence) between the various resource dimensions. Where the resource dimensions are independent, the total niche overlap index is the product of the individual one-dimensional indices (Levins 1968). However, if the resource dimensions are dependent, the total niche overlap is the arithmetic mean of the individual one-dimensional indices. Since the space, habitat, food and time dimensions are not completely dependent or independent, summation (arithmetic mean) niche overlap is an upper bound on the true multi-dimensional niche overlap (May 1975) and product niche overlap is the

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[3] Similarity index is considered a more meaningful index than Spearmans RHO since it takes into consideration actual percentages of consumption of individual species.

lcwer bound.

5.3 Space and Habitat Relations

On a multi-seascn basis, the probability of interspecific encounter (see Table 5.1) between elk and cattle was 46% (1.46 - 100%) greater than it would have been if both species were unifcrmly or randomly distributed. They shared slightly more than half of their combined range within the study area.

Elk were more ubiquitous in their distributicn and occupied more than 50% more sites used by cattle than did cattle occupy sites used by elk (i.e. elk occupied 68% of the sites used by cattle while cattle occupied 42% of the sites used by elk).

Relatively the same ratio of directicnal overlap was indicated by considering abundances. An individual elk, on average, would have found that there had been 1.51 cattle on that same site (over the length of the study) while the average cow would have found that there had been 2.34 elk on any site in which it was located.

In order to determine temporal relationships, seasonal spatial characteristics were examined. The probability of interspecific encounter is slightly higher for elk in spring-summer and total cattle than for elk in the fall-winter period. More specifically, elk in spring showed an extremely high probability of 101% compared to only 28%

Table 5.1. Spatial relationships between elk and cattle (see Appendix A for equations).

Species and Season	Spatial Overlap	Habitat Overlap	Coincidence Index	Association Index	Interspecific Crowding
Total Elk	1.46	1.32	.52	.42	1.51
Total Cattle				.68	2.34
Spring-Summer Elk	1.46	1.04	.24	.31	1.57
Total Cattle				.19	1.01
Fall-Winter Elk[1]	1.37	1.50	.46	.47	1.39
Total Cattle				.45	.86
Spring Elk	2.01	1.16	.34	.48	2.10
Total Cattle				.26	.54
Summer Elk	1.28	1.00	.34	.40	1.33
Total Cattle				.30	.54
Fall Elk[2]	1.37	1.70	.26	.41	1.48
Total Cattle				.19	.54

1 1976-77

2 1977

in summer. The amount of shared combined range was almost one-half as much for elk in spring-summer and total cattle than for elk in fall-winter. The amount of shared combined range is the same for elk in spring as in summer but was substantially less in fall.

Site overlap on each other's ranges was greater for total cattle and elk in fall-winter than for elk in spring-summer. But the increase was substantially more by elk (in fall-winter) on cattle range than by cattle on elk (in fall-wirter) range.

Although the amount of site overlap was greatest in the elk fall-winter period and total cattle, overlap in terms of total numbers decreased. This decrease was proportionally the same for both species.

A separation of the spring-summer period indicated that the site overlap of cattle onto elk range was less in the elk-summer period than in the elk-spring period and overlap in total numbers was much less in the elk-summer period. However, the site overlap of elk onto cattle range was greater in the elk-summer period than in the elk-spring period and overlap in terms of total numbers remained constant. The degree of intraspecific encounter was greater for elk in fall-winter than in spring-summer. Elk intraspecific encounters double in summer over spring and almost triple again in fall, but always were less than cattle.

Habitat overlaps (Table 5.1) were greater in fall-winter than in spring-summer, even though this reversed when a more detailed examination was made of spatial overlaps. Even though elk and cattle preferences for the same broad habitat types were more positively associated in fall-winter than in spring-summer, within these types, preference for microhabitats differed.

On a cumulative seasonal basis (for elk), 57% of all elk fecal groups and 67% of all cattle fecal groups were located in the grassland and coniferous forest cover types (Tables 3.3 and 3.8), although cattle preferred other types to a significant degree. During summer (for elk) however, grasslands had significantly fewer pellets groupings than expected. Both cattle and elk (in the fall and fall-winter period) avoided deciduous forest but in spring-summer, elk neither preferred nor avoided this type.

On a cumulative seasonal basis (elk), only pine-aspen parklands and grassland bench areas were preferred by both elk and cattle with aspen spruce, spruce-aspen, and spruce wetlands avoided by both (Tables 3.4 and 3.9). During summer however, elk neither preferred nor avoided the grassland bench and aspen-spruce associations.

5.4 Forage Resource

Total elk and cattle diets were highly similar at 73% (Table 5.2). Fall elk and spring elk with total cattle had the highest degree of similarity (>70%) than elk and cattle at any other period. Summer elk and total cattle had the lowest degree of similarity (43%), with June and August being especially low. During spring and summer, elk chose their food species in the order most similar as cattle than during any other period (Spearmans RHO, Table 5.2).

Festuca spp. received the highest degree of use by both total elk and total cattle (Tables 4.1 and 4.2). Other than Festuca spp., only Carex spp., Danthonia spp. and species of the Potentilla - Geum group received more than 1% use by both ungulates. There were no other plants utilized by cattle that received over 1% use. However, elk consumed fairly high proportions of Shepherdia - Elaegnus and Salix spp. (5.3% and 4.2%, respectively).

Festuca spp. were only about one-half as important to elk during summer as to cattle and were more important to elk (than cattle) during fall-winter. Coincident with this summer decrease in grass use by elk was a concurrent increase in use of browse, whereas browse use remained consistently low by cattle in the summer and fall periods.

Table 5.2. Percentage similarities and rank correlations of seasonal cattle vs. elk diets.

Species and Season	% Similarity	Spearmans RHO[1]
Total Cattle & Total Elk	73	.49
Total Cattle & Spring/Summer Elk	58	.53
Total Cattle & Fall/Winter Elk	68	.34
Total Cattle & Winter Elk	66	.36
Total Cattle & Spring Elk	70	.42
Total Cattle & Summer Elk	43	.56
June Cattle & June Elk	41	.32
July Cattle & July Elk	66	.29
August Cattle & August Elk	19	.21
September Cattle & September Elk	76	.09

1 These are all significant at the 5% level.

5.5 Niche Overlap

Niche overlap refers only to the dimensions of space, habitat, food and time. Since there is only a moderate amount of distributional overlap (<.27, Table 5.3), product niche overlap is probably more accurate (Anthony and Smith 1977). To the extent that this overall index is representative of dimensional overlaps, cattle and elk have the highest degree of niche overlap during fall-winter (for elk) and total cattle than during spring-summer (for elk) and total cattle. However, when the seasons are subdivided, there is the highest degree of niche overlap between elk in spring and total cattle while during summer, overlap was less than one-half of the spring period.

5.6 Discussion

One of the commonly expressed rationales for doing comparative studies between herbivores, especially wild ungulates and domestic stock, is the need to estimate carrying capacities or grazing capacities (Stoddard et al. 1975) for various combinations of these species on land designated for multiple use. Information on resource partitioning is needed to calculate these carrying capacities.

Approximately 40% or 7600 ha (Section 2.1) of the park consists of open grassland areas which, in 1978, produced approximately 15.5 M kg of forage (Table 4.4) of which 3.7 M

Table 5.3. Indices of overlap in spatial distributions, habitat selection and food habits between elk and cattle in selected periods.

Season and Species	Spatial Distribution (S)	Habitat Selection (H)	Distribution Overlap SxH	Food Habits (F)	Niche (SxHxF) product	Overlap (S+H+F)/3 summation
Total Cattle, Total Elk	.37	.72	.26	.73	.19	.61
Total Cattle, Spring/Summer Elk	.30	.60	.18	.58	.10	.49
Total Cattle, Fall/Winter Elk	.28	.81	.23	.68	.15	.49
Total Cattle, Spring Elk	.35	.62	.22	.70	.15	.55
Total Cattle, Summer Elk	.30	.56	.17	.43	.07	.43
Total Cattle, Fall Elk	.21	.78	.16	.76	.12	.58

kg were consumed by grazing herbivores. Assuming that there were at least 550 elk (512 in the February, 1978 survey + spring births) in the study area during the summer of 1978 and that elk consume 67% of the forage consumed by one animal unit (or 302 kg/month) (Heady 1975), then the elk would have consumed 830,500 kg of forage for the 5 month grazing (cattle) period of about May 15 to October 15. The diet of the elk for the spring, summer and September period consisted of about 50% (range of 45 - 60%) grassland species (Table 4.2), therefore elk would have consumed about 415,250 kg or 11.1% of forage produced on the non-forested areas of the park. There were 10,431 AUM's of cattle in the park for the 1978 grazing season and these animals consumed an estimated 4,735,674 kg of forage (1 animal unit month consumes 454 kg of forage - Heady 1975) of which an estimated 70% (range of 65 - 75%) came from non-forested habitats (Table 4.1). This would result in 3,314,972 kg or 88.7% of the non-forested areas' forage being consumed by cattle. The combined consumption, of these two ungulates, of forage produced on the grassland areas is 3,730,222 kg or 99.8% of that which was found to be utilized by the exclosure core data. Exclosure cone clipping data must be interpreted with caution, since there is confusion in the literature regarding their effects on herbage yields. While Cowlisshaw (1951) found that herbage yields increased under a wire mesh exclosure cone, Dobb and Elliot (1964) found

that there was a 15% reduction in herbage yield and a 53% decrease in seed yield when pasture sampling cages were placed on creeping red fescue (Festuca rubra) in early May and removed in early August.

These calculations leave 30% of the cattle's diet or an estimated 1,420,702 kg and 50% or 415,250 kg of the elk's diet being derived from forested habitat. No data were gathered on productivity, standing crop, or utilization of forage in forested habitats (except for winter twig information).

From the information on diet preferences, it would appear that within forested habitats, cattle derive the vast majority of their diet from graminoid type plants as opposed to browse or forbs. This is consistent with their use of non-forested habitats. Elk however, derive much of their summer diet (perhaps as high as 45-50%) from browse plants.

On a temporal basis, summer grazing cattle can potentially have a substantial effect on wintering elk. In mild winters (as in most of the winters in the early to mid 1970's) after a growing season of high productivity (like that of 1978) and a grazing season of comparatively low cattle AUM's (as in 1978) there would be much forage available for wintering elk on their preferred ranges. However, in relatively severe winters (as in 1977-78); after a growing season of low productivity (as in 1977) and a grazing season of comparatively high cattle AUM's (as in

1977) the amount of forage available to wintering elk would be greatly reduced. Some calculations can illustrate this point. If the preferred winter elk range in mild winters is areas VF, RHF, PP, STP, 1/2 of WF and 1/2 of SFL and SG then the amount of forage on these ranges at the beginning of October (after cattle grazing has been completed) would be about 4 M kg (calculated from Table 4.4) after a growing and grazing season as in 1978. Assuming that 15% of this production is unpalatable (which is reasonable considering the grassland composition, Klumph 1978 and elk dietary preference, Table 4.2), only 75% is available for the whole winter due to decomposition, trampling etc., and it is safe to graze 70% of the net primary productivity during winter months (Heady 1975), this would leave approximately 1.8 M kg of forage on these preferred areas. This could support about 740 elk for an 8 month winter period (1 elk = .67 AU's). If, however, the range is restricted in severe winters to areas RHF, 1/4 of WF and 1/6 of SFL and SC, then about 180 elk could be supported. These calculations however, do not fully reflect elk preferences. Movement out of the study area may occur well before these total calculated values are consumed (see Section 3.432 and Appendix A). The amount of utilization by cattle can affect wintering elk, but elk winter habitat selection can be more drastically affected by climatic conditions.

Schoener (1974) generalized that separation on the habitat dimension was the principle method of resource partitioning in a wide range of animal communities (55% of studies reviewed). The food dimension was the second major mode of partitioning (45%) and the time dimension was only rarely the primary dimension (5%). However, "the usefulness of these types of generalizations has not been clearly established particularly when comparisons are restricted to large mammalian grazing systems. It is often difficult to compare the relative significance of various dimensions objectively since both spatial and temporal occupational patterns appear dictated to some degree by food preferences" (Hudson 1976). Arnold (1964), Bell (1971), Ferrar and Walker (1974) and Jarman (1974) felt that habitat utilization by grazing animals is determined largely by the presence of a preferred food supply, although shelter considerations may be important for some species particularly in northern environments. This difficulty in determining the principal method of resource partitioning is exemplified in this study. For example, elk seem to display a dual preference for both features of forage and features of shelter, almost to the point of ambivalence.

For these reasons, dimensions within the measures of niche overlap (space, habitat, food, time) were given equal weight. Assuming the validity of this weighting, interpretation of the niche overlap index is still not a

simple matter as May (1975) points out because of the unknown nature of the relationship between various resource dimensions. However, if product niche overlap is considered more relevant (Anthony and Smith, 1977), then niche overlap between elk and cattle, although highest in the fall-winter period (elk), is only moderate in comparison to Anthony and Smith's (1977) study of mule deer and white-tailed deer.

Chapter 6: RESOURCE PARTITIONING WITH OTHER UNGULATES

RESOURCE PARTITIONING WITH OTHER UNGULATES

6.1 Introduction

Substantial populations of moose and deer exist in Cypress Hills Provincial Park (Section 2.6) and there are potential interactions that may occur between these species and elk and cattle. Examination of resource partitioning of elk and cattle in regards to productivity and utilization of the important forage plants for example, would not be complete unless the other ungulate species were also considered. The apparent poor condition of browse in the park (Dickinson 1968, Gudmunson 1975a and b) combined with known preferences of both moose and deer for browse (Dickinson 1965, Barrett 1972, Kramer 1972, Kowal 1977) also suggested an examination of resource partitioning between these ungulates, elk and cattle.

This chapter presents information of spatial and habitat patterns and food habits on a comparative basis.

6.2 Methods

Information on spatial and habitat distribution patterns and characteristics of deer and moose was developed primarily during inspection of the fecal plot/transects (Section 3.22) examined in June and August of 1977 and 1978. Therefore, information represents a cumulative two-year

period.

The high populations of the Cypress Hills ungulates within a relatively limited aerial extent also suggested the determination of seasonal dietary patterns of moose and deer. Consequently, 50 samples of fecal material of combined fall-winter and 50 samples of combined spring-summer pellets were collected for moose and the same was collected for deer. Each sample consisted of 2 - 3 pellets for moose and 5 - 6 pellets for deer. During winter, many areas had restricted access due to great snow depths so collections were made on the west end of the park, around area VE and RH (see Fig. 3.1 for location of these areas). In preparation for analyses, samples were treated and analyzed in an identical manner to that applied to cattle and elk feces (Section 4.21).

Data analysis proceeded in a similar manner as the data analysis described in preceeding chapters.

6.3 Space and Habitat Resource

6.31 Elk - Moose

On a multi-season basis, the probability of interspecific encounter (Table 6.2) between elk and moose was 30+% less than it would have been if both species were uniformly or randomly distributed. They shared only about 15% (coincidence index) of their combined range within the

Table 6.1. Values of spatial characteristics of moose and deer.

Species and Season	Degree of Selectivity	Intraspecific Crowding
Total Moose	4.34	.66
Total Deer	2.41	.85
Spring/Summer Moose	7.86	.51
Spring/Summer Deer	2.81	.50
Fall/Winter Moose	11.23	1.12
Fall/Winter Deer	2.57	.46

Table 6.2. Values of spatial relationships between various ungulates.

Species and Season	Spatial Overlap	Coincidence Index	Association Index	Interspecific Crowding	Habitat Overlap
Total Elk Total Moose	.64	.15	.09 .46	.09 1.01	.68
Total Elk Total Deer	.91	.39	.28 .65	.16 1.48	1.00
Total Cattle Total Moose	.64	.13	.08 .27	.09 .63	.86
Total Cattle Total Deer	.55	.25	.22 .31	.19 .56	.85
Total Moose Total Deer	1.28	.19	.30 .14	.45 .19	1.03
Spring-summer Elk Spring-summer Moose	.64	.09	.05 .36	.04 .44	.69
Fall-winter Elk Fall-winter Moose	.73	.09	.06 .26	.07 .45	.67
Spring-summer Elk Fall-winter Moose	.73	.12	.07 .37	.07 .48	.76
Spring-summer Elk Spring-summer Deer	1.73	.30	.25 .55	.30 1.14	1.12
Fall-winter Elk Fall-winter Deer	.82	.18	.13 .32	.15 .53	.88
Spring-summer Elk Fall-winter Deer	1.19	.20	.14 .37	.20 .77	1.02
Total Cattle Spring-summer Moose	1.09	.07	.04 .30	.07 1.14	.75
Total Cattle Fall-winter Moose	.64	.08	.05 .21	.06 1.14	1.04
Total Cattle Spring-summer Deer	.73	.20	.14 .34	.13 .78	.96
Total Cattle Fall-winter Deer	.36	.16	.11 .29	.07 .42	.75
Spring-summer Moose Spring-summer Deer	.73	.08	.10 .05	.14 .05	.87
Fall-winter Moose Fall-winter Deer	1.46	.14	.20 .11	.25 .14	.98

study area.

However, elk were more ubiquitous in their distribution and occupied about 5 times as many sites used by moose as moose occupied sites used by elk (i.e. elk occupied 46% of the sites used by moose while moose used only 9% of the sites sustaining elk).

An even stronger directional overlap was indicated when the animals' abundances were taken into consideration. There were more than 10 times as many elk on sites utilized by moose than there were moose on sites utilized by elk. An individual moose, on average, would have found that there had been 1.01 elk in that same site (over the length of the study) while the average elk would have found only 0.09 moose had used any site it used.

An individual moose would have found that there had been 0.7 other moose in that same site over the length of the study while an individual elk would have found that there had been 3.5 other elk (Tables 6.1 and 3.1).

Even though the degree of intraspecific encounter is lower for moose than elk, moose have a much higher degree of spatial selectivity or specialization. The selectivity value of 4.34 for moose indicated that the probability of intraspecific encounter or the probability of 2 moose attempting to utilize the same site over the length of the study was 334% (4.34 - 100%) higher than it would have been if moose were the perfect generalist while the probability

for elk was only 115% higher.

The higher degree of spatial selectivity combined with the low degree of intraspecific encounter for moose indicated a narrow niche breadth in terms of the spatial resource. And in fact the spatial niche breadth of moose was only one quarter that of elk (.09 compared to .36). Moose had the narrowest distribution of the four species of ungulates occurring on the study area.

In order to determine temporal relationships, seasonal spatial characteristics were examined. The probability of interspecific encounter was higher in fall-winter than in spring-summer, although it remained negative. The amount of shared combined range remained the same at 9% for each season.

Site overlap by elk on moose range was greater in spring-summer than in fall-winter but site overlap by moose on elk range was greatest in fall-winter. However, overlap in terms of total numbers of animals was consistently greatest in fall-winter.

The degree of intraspecific encounter was much greater for moose in fall-winter than spring-summer and only slightly greater for elk (Tables 6.1 and 3.1).

This increase in encounters is reflected in the higher degree of spatial selectivity in fall-winter, especially exemplified by moose.

Moose did not make use of all grass canopy cover types (sign was not found in 50 - 75% deciduous or coniferous cover) nor all vegetation associations (parklands pine or poplar wetlands). Pellet groupings representing all seasons deposition occurred on only 11% of the pellet group plots.

Cumulative seasonal sign of moose occurred more frequently than expected in two canopy cover types - deciduous forest and mixed forest - in both of which was found less elk sign than expected. These two types occupied 33% of the total area but contained 59% of all moose fecal piles. Only the grasslands received less sign than expected, again in contrast to elk sign (Table 3.7).

Three vegetation types contained more moose fecal piles than expected: parklands aspen, aspen (slopes) and aspen-spruce, again all were negatively associated with elk sign. Only the pine aspen and grassland bench areas had less sign than expected. These two areas were preferred by elk.

Distribution patterns are defined further by considering temporal characteristics. The relationships to canopy cover types remained the same with opposing preferences and avoidance between elk and moose. Spring-summer patterns however, changed. Whereas elk became much more evenly distributed, showing significant preferences or avoidance for only one cover type, moose maintained a high degree of selectivity with four types preferred or avoided. Moose avoidance of coniferous forest

Table 6.3. Seasonal distribution of moose and deer fecal groups by canopy cover type.

Canopy Cover Type	% of Sampled plot in cover type (n=912)	Total Moose (n=150)		Fall-Winter Moose (n=91)		Spring-Summer Moose (n=59)		Total Deer (n=320)		Fall-Winter Deer (n=160)		Spring-Summer Deer (n=160)	
		%	Affinity Index	%	Affinity Index	%	Affinity Index	%	Affinity Index	%	Affinity Index	%	Affinity Index
1. Grassland, 1/3 of area in tree cover	26.0	13.8	(0.5-)	14.3	(0.6-)	13.6	(0.5-)	14.7	(0.6-)	16.3	(0.6-)	11.9	(0.5-)
2. 30-50% deciduous or coniferous cover	1.9	2.2	(1.2)	2.2	(1.2)	1.7	(0.9)	3.1	(1.6)	1.9	(1.0)	4.4	(2.3+)
3. 50-75% deciduous or coniferous cover	0.8	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	0.9	(1.1)	1.3	(1.6)	0.6	(0.8)
4. Fairly continuous cover with frequent openings	6.6	8.7	(1.3)	8.8	(1.3)	6.8	(1.0)	5.3	(0.8)	4.4	(0.7)	6.3	(1.0)
5. Deciduous forest with or without scattered conifer	12.0	21.7	(1.8+)	20.9	(1.7+)	18.6	(1.6)	15.4	(1.3)	10.6	(0.9)	18.8	(1.6+)
6. Mixed forest	21.3	37.0	(1.7+)	34.1	(1.6+)	50.8	(2.4+)	26.7	(1.3+)	31.3	(1.5+)	23.1	(1.1)
7. Coniferous forest with or without scattered deciduous	12.2	7.2	(0.6)	9.9	(0.8)	1.7	(0.1-)	9.1	(0.7)	10.0	(0.8)	9.4	(0.8)
8. Closed canopy conifer	12.8	6.5	(0.5)	7.7	(0.6)	3.4	(0.3-)	17.3	(1.4+)	15.6	(1.2)	19.4	(1.5+)
9. Dense pine - old burn	6.4	2.9	(0.5)	2.2	(0.3	3.4	(0.5)	7.5	(1.2)	8.8	(1.4)	6.3	(1.0)

Table 6.4. Season distribution of moose and deer fecal groups by vegetation association.

Vegetation Association	% of Sampled plots in association type (n=912)	Total Moose (n=150)		Fall-Winter Moose (n=91)		Spring-Summer Moose (n=60)		Total Deer (n=335)		Fall-Winter Deer (n=165)		Spring-Summer Deer (n=170)	
		%	Affinity Index	%	Affinity Index	%	Affinity Index	%	Affinity Index	%	Affinity Index	%	Affinity Index
Parklands													
Pine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	2.2	2.4	4.5+	0.0	0.0
Pine Aspen	1.5	2.1	1.4	3.3	2.2	0.0	0.0	4.5	3.0+	0.6	0.4	8.2	5.4+
Aspen	4.1	17.7	4.3+	20.9	5.1+	10.0	2.4+	3.9	0.9	4.2	1.0	3.5	0.9
Slopes													
Pine	15.4	9.2	0.6	9.9	0.6	6.7	0.4	20.4	1.3+	19.4	1.3	22.9	1.5+
Pine Aspen	8.7	1.4	0.2-	1.1	0.1-	1.7	0.2	10.8	1.2	9.7	1.1	12.9	1.5
Aspen Pine	6.0	4.3	0.7	3.3	0.6	5.0	0.8	8.4	1.4	4.8	0.8	9.4	1.6
Aspen	6.6	13.5	2.0+	7.7	1.2	16.7	2.5+	6.3	1.0	6.7	1.0	5.9	0.9
Aspen Spruce	7.3	15.6	2.1+	13.2	1.8+	16.7	2.3+	9.0	1.2	10.3	1.4	7.6	1.1
Spruce Aspen	9.7	9.2	1.0	4.4	0.5	15.0	1.6	7.2	0.7	9.1	0.9	5.3	0.5
Pine Spruce	5.0	2.1	0.4	3.3	0.7	0.0	0.0	4.8	1.0	4.8	1.0	5.3	1.1
Spruce Pine	2.8	1.4	0.5	0.0	0.0	3.3	1.2	4.5	1.6	6.1	2.1+	1.2	0.4
Wetlands													
Spruce	4.1	7.1	1.7	14.3	3.5+	10.0	2.4+	2.4	0.6	3.0	0.7	2.4	0.6
Poplar	0.1	0.0	0.0	2.3	20.4+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open Areas													
Grassland Bench	15.4	2.8	0.2-	3.3	0.2-	3.3	0.2-	5.1	0.3-	6.7	0.4-	4.1	0.3-
Grassland non-bench	7.3	7.1	1.0	8.8	1.2	3.3	0.5	8.1	1.1	9.7	1.3	7.1	1.0
Shrubland	5.2	6.4	1.2	4.4	0.8	8.3	1.6	3.3	0.6	2.4	0.5	4.1	0.8

is in opposition to elk preference for this type during this season. Moose avoided closed canopy conifer, continued to avoid grassland areas and preferred mixed forest.

In terms of vegetation associations in fall-winter moose preferred wetland habitats, and especially those with a poplar overstory; this type was avoided by elk. parklands aspen and aspen-spruce was also preferred by moose but avoided by elk. The grassland bench wereas are the only open areas significantly avoided by moose, with non-bench and shrubland areas not significantly avoided nor preferred. The pine-aspen type also had fewer pellet groupings than expected. Spring-summer moose distribution patterns remained very similar to the fall-winter period, with aspen forests also highly preferred habitats. This type was significantly neither preferred nor avoided by elk in spring-summer.

6.32 Elk - Deer

On a multi-season basis, the probability of interspecific encounter between elk and deer was only slightly less than it would have been if both species were randomly associated. They shared about 39% of their combined range within the study area.

Elk occupied about 65% of the sites used by deer while deer occupied 28% of the sites used by elk.

This strong overlap of elk onto sites used by deer is reinforced by the ninefold increase in elk numbers on sites

utilized by deer over the numbers of deer using elk sites. An individual deer, on average, would have found that there had been 1.48 elk in that same site (over the length of the study) while the average elk would have found .16 deer.

The amount of intraspecific encounter was less for deer and amounted to only 15% that of elk. But even though the actual amount of intraspecific encounter was lower, deer had a slightly higher degree of spatial selectivity or specialization. The probability of two deer attempting to utilize the same site over the length of the study was 157% higher than it would have been if deer were the perfect generalwast while the probability for elk is 115% higher.

The deer's spatial niche breadth was one third that of elk. An examination of seasonal spatial relationships indicated great differences between spring-summer and fall-winter.

The probability of interspecific encounter (or the degree of spatial overlap) was 73% higher in spring-summer than it would have been if both species were uniformly or randomly distributed. This highly significant degree of positive association contrasted with fall-winter in which there was a significant lack of association. The amount of shared confined range was, expectedly, also higher in spring-summer.

The ratio of elk/deer site overlap remained approximately equivalent in all periods with deer occupying

slightly less than half of sites used by elk than elk occupied sites used by deer, although the overlap itself was greatest in spring-summer. Overlap in terms of total numbers of animals was consistent with site overlap in that the spring-summer period received the highest amount.

The degree of intraspecific encounter for deer remained equivalent in both seasonal periods compared to slightly increased encounters for elk in fall-winter.

Deer exhibited a decreased degree of spatial selectivity in fall-winter which contrasted with the trend exhibited by elk.

Deer made at least some use of all canopy cover types and nearly all vegetation associations (except poplar wetlands). Pellet groupings representing year-round deposition occurred on 25% of pellet group plots.

Cumulative seasonal deer pellet groupings occurred more frequently than expected on two canopy cover types - mixed forest (which was significantly avoided by elk) and closed canopy conifer. These two types occupied 34% of the total number of plots and contained 44% of the total deer fecal groups (Table 6.3). Only two vegetation associations had deer sign more frequently than expected - the parklands pine aspen type and the pine slope types - both of which also contained more elk pellet groupings than expected. Grassland bench areas were avoided by deer to a significant degree but were preferred by elk (Table 3.8).

Deer avoided the grassland cover type in both fall-winter and spring-summer whereas elk preferred this type in fall-winter and avoided it in the summer. However deer sign occurred more frequently than expected in a habitat type adjacent to the open areas in the spring-summer, the 30 - 50% deciduous or coniferous cover; especially if it consisted of pine-aspen. Deciduous forest was preferred during spring-summer and was neither preferred nor avoided by elk in this period. Pine slopes were preferred by both elk and deer in spring-summer.

6.33 Cattle - Moose

On a multi-season basis, the probability of interspecific encounter between cattle and moose was 36% less than it would have been if both species were uniformly or randomly distributed. They shared only 13% of their combined range within the study area (Table 6.2).

Cattle occupied about 27% of the sites used by moose while moose only occupied about 8% of the sites used by cattle.

This strong directional overlap was reinforced by the sevenfold increase in cattle encounters with moose than in moose encounters with cattle. An individual moose, on average, would have found that there had been .63 cattle in that same site (over the length of the study) while an individual cow would have only found .09 moose on any site

it used.

A cow would have found that there had been 4.08 other cattle in that same site over the length of the study while a moose would have found that there had been only .66 other moose.

Moose had a greater degree of spatial selectivity than cattle. The probability of two moose attempting to utilize the same site over the length of the study was 334% higher than it would have been if moose were randomly distributed while the probability for cattle was 209% higher.

Temporal considerations indicated that only in fall-winter was there a negative degree of spatial overlap. There was only a very slight degree of positive overlap in spring-summer. The amount of shared combined range remained relatively the same at 7 - 8% for both seasons.

Site overlap by cattle on moose range was greater in spring-summer than in fall-winter. However, overlap in terms of total numbers of animals remained about the same for both seasons.

The degree of intraspecific encounter for moose was more than doubled in fall-winter over spring-summer and thwas is reflected in the greater degree of spatial selectivity during fall-winter.

Although moose and cattle had a negative degree of overlap on a habitat basis (Table 6.1) in spring-summer, they had a postive degree of spatial overlap within at least

some habitats. Fall-winter moose and total cattle habitat overlap were about the same as if they were randomly distributed but on a microscale, they had a fairly large degree of negative association (-36%).

On a cumulative seasonal basis moose had more opposing affinities than cattle for the same cover types (i.e. grassland bench areas, deciduous forest and mixed forest). The same opposition occurs in the fall-winter seasons. However, in spring-summer, both moose and cattle avoided closed canopy conifer. Moose fecal piles occurred much less than expected in coniferous forest in the spring-summer whereas cattle neither preferred nor avoided this type (Tables 6.3 and 3.2).

Moose and cattle had similar positive preferences for parklands aspen vegetation association on a cumulative seasonal basis (Tables 6.4 and 3.3). All other significant moose affinities were in opposition to those of cattle. Both had negative affinities for pine-aspen slopes. Both moose and cattle have positive affinities for spruce wetlands. All other seasonal moose affinities that were significant were opposite to those of cattle.

6.34 Cattle - Deer

On a multi-season basis, the probability of interspecific encounter (Table 6.2) between cattle and deer was 45% less than it would have been if both species were

distributed uniformly or randomly. They shared only 25% of their combined range within the study area.

Deer occupied 22% of the sites utilized by cattle while cattle occupied 31% of the sites used by deer. In terms of total numbers, however, there was a stronger directional overlap. Three times as many cattle occurred on sites used by deer than deer occurred on sites utilized by cattle (0.19 deer on cattle sites and 0.56 cattle on deer sites).

Deer had only one-half the degree of spatial selectivity as did cattle (Tables 6.1 and 3.1) (141% higher for deer and 289% higher for cattle than if either were the perfect gereralist).

During spring-summer the probability of interspecific encounter was less than 50% that of fall-winter although both periods had a negative degree (-27% and -64% respectively). This was also reflected in the slightly higher degree of combined shared ranges (coincidence index, Table 6.2) the greater degree of directional overlap by both species on the other during spring-summer (association index and interspecific crowding).

Overlap on a gross scale (habitat overlap, Table 6.2) was negative, as it was on a more micro scale. On a cumulative seasonal basis, in those canopy cover types in which deer had significant affinities (either positive or negative), cattle had opposing affinities to a significant degree (grassland mixed forest, closed canopy conifer). The

same relationship to cover types applied for deer during fall-winter and total cattle. However, during spring-summer, there was one type which was preferred by both, the 30 - 50% deciduous or coniferous cover type. Both had a preference for the parklands pine-aspen vegetation association (Tables 6.4 and 3.3) but had opposing affinities for pine slopes and grassland bench on a cumulative seasonal and spring-summer basis. For deer during fall-winter and total cattle however, deer had a significant preference for spruce-pine slopes while cattle showed a significant avoidance of this type.

6.4 Forage Resources

Total elk and moose diets were not very similar at 16% (Table 6.6) although the order of choice of food items was relatively high (.46, Spearman's RHC, Table 6.6). Whereas elk had a preference for graminoids (78% of the total diet) (Tables 6.5 and 4.2) and a low preference for browse (15%) moose had opposing preferences (95% for browse and only 4% for graminoids). However, the most highly preferred food items by moose (Salix spp. and the Shepherdia - Elaagnus group) were also the most highly preferred browse items by elk.

Spring-summer elk and moose diets however were quite similar (47%) with highly ranked ordering of forage species. The shift is due mainly to a higher preference for browse by elk during spring-summer. Fall-winter diets were highly

Table 6.5. Percentages of plant fragments in samples of moose and deer feces, 1977-78.

Species	MOOSE Fall Winter	MOOSE Spring Summer	MOOSE Total	DEER Fall Winter	DEER Spring Summer	DEER Total
Grasses						
Agropyron spp.				1.3		0.6
Bromus spp.	0.6	0.2	0.4	3.1	0.7	1.9
Danthonia spp.				0.3		0.1
Festuca spp.	0.6	4.4	2.5	2.1	6.4	4.2
Koeleria cristata				.3		0.1
Stipa spp.					0.2	0.1
Unknown grass	0.2		0.1			
Total Grasses	1.3	4.6	3.0	7.0	7.4	7.0
Sedges & Rushes						
Carex spp.		1.3	0.6	1.0	0.7	0.9
Juncus spp.		0.2	0.1			
Total Sedges & Rushes		1.5	.7	1.0	0.7	0.9
Total graminoids	1.3	6.1	3.7	8.0	8.1	7.9
Forbs						
Antennaria spp.				.3		0.1
Artemesia spp.				9.3		4.7
Astragalus spp.		0.2	0.1	2.1	0.7	1.4
Compositae spp.				1.3		0.6
Cryplantha spp.				0.3		0.1
Lupinus spp.		0.4	0.2	0.3	0.2	0.3
Phlox spp.				1.5	0.2	0.9
Potentilla-Geum spp.		1.5	0.1		8.3	4.1
Total Forbs		2.1	0.4	15.0	9.5	12.2
Shrubs						
Juniperus spp.				3.9		2.0
Picea glauca				3.7	0.2	2.0
Pinus contorta	0.8	0.4	0.6	25.4	0.7	13.1
Populus-Amelanchier spp.		2.6	1.3	4.5	1.4	3.0
Prunus spp.		0.2	0.1	0.3		0.1
Rosa spp.				1.3	9.7	5.5
Rubus spp.		0.2	0.1	0.5	11.9	6.2
Salix spp.	70.5	60.1	65.3	21.0	36.9	29.0
Shepherdia-Eleagnus spp.	13.9	28.3	21.1	16.5	20.6	18.6
Symphoricarpos spp.					0.9	0.5
Unknown bark	13.6		6.8			
Total Shrubs	98.7	91.8	95.3	77.0	82.4	80

Table 6.6. Percentage similarities and rank correlations of seasonal herbivore diets.

Species and Season	% Similarity	Spearmans RHO
Total Elk & Total Moose	16	.46
Total Elk & Total Deer	55	.53
Total Cattle & Total Moose	6	.18
Total Cattle & Total Deer	9	.06
Total Moose & Total Deer	54	.38
Spring/Summer Elk & Spring/Summer Moose	47	.71
Fall/Winter Elk & Fall/Winter Moose	8	.45
Spring/Summer Elk & Spring/Summer Deer	46	.69
Fall/Winter Elk & Fall/Winter Deer	14	.23
Total Cattle & Spring/Summer Deer	10	.18
Total Cattle & Fall/Winter Deer	4	.07
Total Cattle & Spring/Summer Moose	4	.39
Total Cattle & Fall/Winter Moose	2	.22
Spring/Summer Deer & Spring/Summer Moose	67	.56
Fall/Winter Deer & Fall/Winter Moose	39	.48

dissimilar.

Total elk and deer diets showed a fairly high degree of similarity (55%, Table 6.6). However this fairly high similarity was only during spring-summer when both showed large amounts of *Salix* spp., *Shepherdia* - *Eleagnus*, *Potentilla* - *Geum* group, *Festuca* spp., *Rubus* spp. and *Rosa* spp. (Tables 6.5 and 4.2). During fall-winter, deer had a much higher preference for browse (77% of total diet) than did elk (15.3%). The change in diet similarities is due to a shifting in the preferences of elk between these major periods.

Cattle and moose showed a very low degree of diet similarity, in fact, the lowest of any pair of ungulates (6%, Table 6.6). Browse items contributed only about 1% of cattle diet but contributed about 95% of moose diets. The opposite applies to graminoids (Tables 6.5 and 4.1). Similarities were not much different between the two major seasons.

Similarities in diet between cattle and deer were also very low. In fact, the order of choice of plant species was even less similar than for cattle and moose (Table 6.6). Deer had an annual and seasonal preference for browse rather than forbs (and especially graminoids), whereas the preferences of cattle were opposed to this order (Tables 6.5 and 4.1).

6.5 Niche Overlaps

Since combined niche overlap indices (of space, habitat and food) represent niche overlaps, total elk and deer have as high a niche overlap (Table 6.7) as elk and cattle (Table 5.3) assuming that product niche overlap is most accurate (Anthony and Smith 1977) and a much higher overlap than any other pair of ungulates. This high overlap, however, existed only during spring-summer. Niche overlaps of cattle with both moose and deer were very low in all seasons. Elk and moose overlap was also quite low, being only slightly higher in spring-summer than in fall-winter.

6.6 Discussion

The low values of niche overlap between elk/cattle and moose and deer may be somewhat misleading. The reported past declines of moose and deer populations due to deteriorating browse supplies would seem to contradict the values. To imply that intraspecies competition is the only cause of the declines does not seem reasonable since all ungulate species in the park are at least partially consuming the same food groups - i.e. browse. It may be that the 1.3% consumption of browse by 12,000 AUM's of cattle and the 15.3% consumption of browse by 500 elk may cause significant depletions of this resource for subsequent users. Productivity and utilization measurements of the browse indicate that use was heavy.

Table 6.7. Indices of overlap in spatial distributions, habitat selection and food habits between various ungulates in selected periods.

Species and Season	Spatial Distribution (S)	Habitat Selection (H)	Food Habits (F)	Niche Overlap (SxHxF) product	Niche Overlap (S+H+F)/3 summation
Total Elk & Total Moose	.36	.44	.16	.03	.32
Total Elk & Total Deer	.47	.73	.55	.19	.58
Total Cattle & Total Moose	.24	.53	.06	.01	.28
Total Cattle & Total Deer	.21	.55	.09	.01	.28
Spring/Summer Elk & Spring/Summer Moose	.27	.41	.47	.05	.38
Fall/Winter Elk & Fall/Winter Moose	.23	.43	.08	.01	.25
Spring/Summer Elk & Spring/Summer Deer	.44	.79	.46	.16	.56
Fall/Winter Elk & Fall/Winter Deer	.21	.65	.14	.02	.33
Total Cattle & Spring/Summer Deer	.30	.55	.10	.02	.32
Total Cattle & Fall/Winter Deer	.22	.52	.04	<.01	.26
Total Cattle & Spring/Summer Moose	.28	.46	.04	.01	.26
Total Cattle & Fall/Winter Moose	.22	.51	.02	<.01	.25

The indices of niche overlap were as high between elk and deer as they were between elk and cattle. Elk and moose both have a browse advantage over deer due to their ability to move and forage through deeper snow and reach higher to obtain food (Case 1938, Cliff 1939).

Chapter 7: DISCUSSION

D I S C U S S I O N

7.C Discussion

Niche differentiation by elk and cattle along the dimensions of habitat (space) food and time was analyzed partially by a consideration of indices of spatial, habitat and food overlap on a seasonal basis. Although there was a positive degree of spatial and habitat overlap on an annual and seasonal basis, the amount of overlap was only moderate and the highest overlaps were non-contemporaneous. Degree of selectivity and distributional uniformity indices calculated from plot data revealed the nature of distribution on a spatial basis. Of particular interest was the high frequency of occurrence of elk fecal groups compared to cattle fecal groups. This difference is amplified when the populations of the two species are considered. This may indicate that elk adopt a more non-specialist strategy than do cattle. Although it was difficult to compare the relative significance of various dimensions objectively, it appeared that the food dimension was most important to cattle in terms of habitat utilization, while elk seemed to display a dual preference for both features of forage and shelter, almost to the point of ambivalence.

During late spring, summer and early fall, which is the only time of year when both species are in the park

together, cattle had very strong preferences for open grassland areas and those parkland areas which are located immediately adjacent to the grasslands. Elk, on the other hand, had strong preferences for forested habitats at this time of year. The greatest spatial and habitat overlaps were non-contemporaneous. For example, it was during the spring period that elk overlapped most on areas used by cattle during the summer. Annual shifts in summer preferences were characterized by stronger preferences in years of high forage productivity. During years of low forage productivity, distribution of both species was more ubiquitous.

Annual shifts in regional distribution during winter by elk were related to the severity of winter climatic conditions. In winters in which most of the grassland bench areas had heavy snowfall with severe crusting, the elk habitually congregated mostly in one large herd and spent the winter in one particular area. In winters of less severe conditions, there were several smaller herds scattered throughout the park.

Diets of the cattle and elk were highly similar on an annual basis in Cypress Hills Provincial Park and were especially similar for elk during winter and cattle during summer. Similarities are highest in the consumption of *Festuca* spp. (likely *scabrella*). In summer, elk consumed large quantities of browse. When the diets of the two

species were compared during the same months, elk had a much greater variation in diet. This again may reflect the more non-specialist strategy of elk.

Although there are niche differences, to varying degrees, between elk and cattle along the dimensions of habitat (space), food and time, this conclusion by itself is not particularly enlightening, since by definition, species are different. Showing that two species utilize different parts of a distribution of a given resource is not a demonstration of the absence of competition. The importance of the differences lies in their effects on the species themselves. It is perhaps important to know if competition is occurring, and if it is, to what level of severity.

It is recognized that indications of spatial, habitat and food overlap may be taken as evidence either for or against competition (Sale 1974, Hudson et al. 1976), as such overlap may be functionally synergistic at least in some grazing systems (Bell 1971). Inaccurate interpretations may result when only one or two parameters are considered. However, the likelihood of misinterpretation reduces when many parameters are considered.

Competitive interactions between two species can be split into "interference" and "exploitation" (Miller 1967) where interference refers to the capability of a superior competitor to restrict access to a common resource and exploitation refers to the capability of a superior

competitor to utilize more of a common resource when access to that resource is unlimited. Miller contends that, as a general rule, interference seems to be more important in the higher taxa while exploitation is a greater factor in lower animals. However, there seems to be some indication that this is not true of large ungulates (Compton 1975, Telfer 1974).

Although behavioural observations were not quantified in this study, elk and cattle were observed feeding in close proximity to each other (within 10 m) on many occasions without interaction. These observations were made within two days of cattle being released in the park in spring. Often, cattle were located between grazing elk and shelter. This behavioural information would suggest that interference competition was not occurring.

Exploitation competition would, in this study, be the form of competition that potentially predominates. Since diets of elk and cattle were highly similar, each species could be expected to exploit the food resource of the other. However, it should be emphasized that showing that two species utilize the same portion of a distribution of a resource is not a demonstration of extant competition (Conley 1976). Since diet similarity was highest for elk and cattle during winter (for elk) and summer (for cattle) and since it is the winter period that is the most critical for ungulates (Pounds 1974), the direction of potential

competition is towards cattle exploiting the food resources of elk. This potential competition becomes more cogent when utilization of forage production is considered. In some areas, utilization was 75% of standing crop. However, the utilization/production ratio varies not only with changes in ungulate populations but with annual changes in forage productivity due to climatic changes. In those areas and years when cattle consume large percentages of the yearly forage production they may be exploitatively competing with elk.

However, the biological relevence of this form and this extent of competition remains problematical, as grazing and habitat relationships are subtle and complex. For example, the preferred winter range of elk during severe winters is located in an area that has historically received little use by cattle during the summer grazing season. Yet the choice of this area by elk is most likely more relateable to comparatively shallow snow depths and little surface crusting than to lack of summer use by cattle.

There is a danger of using "static", short term data to infer the presence or absence of competition when in another time, the interactive phenomena may reverse. The lack of severe competition occurring between elk and cattle over the two year period of this study may not imply that substantial competition has never occurred between these species or that competition has not been the formative and active factor

which created and maintained the niche differences that do exist (Miller 1967). The fact that the park population of elk had increased, in the presence of continuous cattle grazing, from a population of less than thirty in 1938 to over 500 in 1977, would superficially indicate that competition, if it is occurring, is minimal and of no relevance.

Sale (1974) feels that the only way to determine whether competition is occurring is to measure the fundamental niches of the species. The limitations of this study precluded this measurement and only realized niches were studied (fundamental and realized niches are as defined by Hutchinson 1957).

Indices of niche overlap indicated that overlaps of cattle and elk were only moderate at any time of year, but that overlap was greatest during fall/winter than during spring/summer. This measurement must be interpreted with caution because: a) only 3 niche dimensions were considered, therefore it is potentially possible that the important dimension was missed and b) each of the three dimensions were weighted equally, when in fact, there are strong indications that the effects of each dimension vary substantially between species.

The consideration of resource partitioning between elk and cattle and the other ungulates of the park seems to indicate that there is more potential for competition of elk

with moose and deer than between elk and cattle. This conclusion is derived from the studies on browse and herb standing crop, productivity and utilization. While average utilization of the herb forage was only 24% of the productivity in 1978, 50% of all twigs produced in the park (of those species studied) were browsed, with some species incurring browsing of 63% and 74%. The comparatively short supply of this food type, combined with the dependence of both deer and moose on browse, and the summer preference of elk for browse items would place considerable pressure on the ability of this food supply to meet the demands for it. Since elk have the most catholic diet of all the park ungulates, the direction of the potential extant competition is clear. Elk are the superior competitors.

SUMMARY

1. Elk (*Cervus elaphus*) were reintroduced to the Cypress Hills area probably in 1938 and were first noted in the study area (Cypress Hills Provincial Park, Alberta) in the mid 1940's. By 1956 populations in West Block, Saskatchewan and the study area supposedly reached 250 - 300. By 1977, populations reached 882 (487 in study area). In the fall of 1978 hunters removed 249 from the study area.

2. Cattle were brought to the Cypress Hills in the late 1870's and reached present day populations well before 1920. There is an annual cattle grazing season in the study area lasting approximately 5 months; from May 15 to October 15. During the 3 years in which accurate records were kept, use of the study area by the three major stock associations averaged 12,407 AUM's annually.

3. Information on habitat utilization, food habits and relations with other ungulates was obtained during a study of resource partitioning by elk and cattle in Cypress Hills Provincial Park, Alberta, during May to August of 1977 and 1978.

4. Habitats in the study area were classified in two ways: one based on canopy coverage of the vegetation and one based on the plant communities described by previous researchers.

5. On an annual basis, cattle are more highly selective than elk in their spatial preferences. However, on a seasonal basis, elk in fall were more selective than cattle.

6. Cattle made at least some use of all habitats although quantitative analysis suggested preferential use of grassland areas, parklands and wetlands as compared to the forested slopes.

7. Elk also made at least some use of all habitat types, although grasslands, parklands and pine and pine-aspen slopes were preferred as compared to areas containing spruce trees, pure deciduous trees or wetlands.

8. Seasonal shifts in the habitat preferences of elk were towards more forested areas and away from grassland areas in summer as compared to winter.

9. Annual and regional shifts in habitat preferences for both elk and cattle during the summer were very slight. Annual shifts may be related to annual changes in vegetative productivity.

10. Spring shifts in regional preferences of elk were relatable to the timing of snowmelt and to the severity of the climatic conditions during the past winter.

11. Regional shifts in habitat preferences on an annual basis for elk during fall-winter were relatable to annual

climatic variations. During relatively mild winters of shallow snows, the elk had a ubiquitous distribution. They spent the winter in several small herds on and adjacent to the 4 - 6 major bench areas of the park. During relatively severe winters the elk congregated mostly in one major herd which was consistently located in the northeast part of the park. More elk move farther outside the park in severe winters than in mild winters.

12. The density of tourist traffic in the park may have affected habitat selection of elk.

13. Habitat utilization by cattle appeared to be affected primarily by forage availability. Habitat utilization by elk appeared to have been affected by both forage and cover characteristics.

14. Grasses were the most important dietary constituent for both elk and cattle, with Festuca spp. (likely scabrella) the most heavily utilized food item. Sedges and rushes were the second most important food group for cattle and browse was the second most important food group for elk. Food preferences changed little for cattle for the months of June to September. However, for elk, browse greatly increased in importance during the summer. Elk and cattle diets were 73% similar on an annual basis. Similarity was greatest for elk during spring and total cattle and least for elk and cattle

in August.

15. Of eight shrub species studied Salix spp. and Cornus stolonifera had the highest average twig production in 1977. These two species also had the highest average utilization per twig. The total percentage of twigs browsed was 50.2% and utilization was 18.6% of production. Deciduous forest habitat was the type most heavily used and grassland areas and dense pine areas had the lowest utilization. Of the species studied total browse production in 1977 is estimated to be 56,034 kg for the study area.

16. Standing crop of herbs in 1977 for the park averaged 82.3 g/m². In 1978 production on the same sites as 1977 averaged 162.8 g/m². This difference between the two years is due to the below average precipitation in 1977 and the above average precipitation in 1978. Productivity in heavily grazed areas averaged 185.4 g/m² while productivity on lightly grazed areas averaged 254.6 g/m² in 1978. Total production on the open grassland areas in 1978 is estimated to be 15,532 x 10^3 kg. Utilization of this production is estimated at 3,737 x 10^3 kg.

17. Spatial overlap of elk and cattle is greatest during spring-summer as compared to elk in fall-winter and total cattle. When spring/summer is broken down, however, overlap is greatest during spring for elk and summer for cattle.

18. Indices of niche overlap indicate that although the potential for competition is greatest for elk and cattle during fall-winter (for elk) and total cattle, the values at any time are only moderate.

19. Moose and deer and elk and cattle were the only two pair of ungulates that had a positive degree of spatial overlap on an annual basis. However, elk and deer and cattle and moose had positive overlaps during spring-summer.

20. Moose preferred habitats different from those preferred by elk during all seasons. Deer and elk preferred some similar habitats, especially the parklands pine-aspen and the pine slope types. Moose and deer preferred habitat types different from those preferred by cattle during all seasons.

21. Moose and elk diets were only 16% similar on an annual basis. But during summer, similarities were much greater. Deer and elk diets were 55% similar with similarities being highest during spring-summer when both consumed large quantities of browse. Diet similarities between cattle and moose and deer were low during all seasons.

22. The potential for competition was as great for elk and deer as it was for elk and cattle.

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Appendices

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Appendix A

Habitat Utilization

List of Tables

1. Spring response of elk to individual features of habitat.

2. Summer response of elk to individual features of habitat.

List of Figures

1. Distance elk moved out of the park in winter of 1977/78.

2. Elk pellets/ha for elk winter range - 1976/77 and 1977/78.

3. Major cover types - Cypress Hills Provincial Park (see foldout in back cover).

Table . Spring Response of Elk to individual features of habitat.

Multiple Relationships: Generalized R^2 = .18 ; Multiple R = .26 ; Multiple R^2 = .06

	Direction of Response	eta	beta	MCA Coefficient
Conifer Cover				
None	-			
1 - 5%	0			
6 -25	+			
26 -50	0			
51 -75	0			
76+	0			
Deciduous Cover		.008	0.102	
None	-			-0.258
1 - 5%	0			0.168
6 -25	0			0.309
26 -50	0			0.313
51 -75	+			0.781
76 -100	0			0.343
Tree Cover				
None	-			
1 -10%	0			
11 -25	0			
26 -50	+			
50+	0			
1st Major Tree		.029	.100	
None	0			0.174
Populus trem.	0			-0.374
P. balsam.	0			-0.186
Picea glauca	-			-0.139
Pinus contorta	+			0.266
2nd Major Tree		.014	.023	
None	-			.043
Populus trem.	+			-0.241
P. balsam.	0			-0.262
Picea glauca	0			- .018
Pinus contorta	+			0.213
Shrub Cover				
None	0			
1 - 5%	0			
6 -25	-			
26 -50	-			
51 -75	0			
76+	0			
1st Major Shrub		.021	.012	
None	0			.056
Rosa spp.	0			.004
Symphoricarpos spp.	0			- .046
Shepherdia canad.	+			0.341
Eleagnus com.	0			.027
Amelanchier alni.	-			-0.106
Potentilla fru.	0			- .027
Picea glauca	0			0.127
Other	0			- .045
2nd Major Shrub		.011	.005	
None	0			.006
Rosa spp.	0			.038
Symphoricarpos spp.	0			- .080
Shepherdia canad.	0			.000
Eleagnus com.	0			.047
Amelanchier alni.	0			- .023
Potentilla fru.	0			- .035
Picea glauca	0			- .010
Other	+			0.145
Herb Cover				
None	0			
1 - 5%	0			
6 -25	0			
26 -50	0			
51 -75	0			
76+	0			
Grass Cover		.017	.011	
None	0			-0.188
1 - 5%	0			-0.142
6 -25	0			.134
26 -50	0			- .024
51 -75	0			0.152
76+	0			.047

Table continued.

	Direction of Response	eta	beta	MCA Coefficient
1st Major Grass		.007	.017	
None	0			- .045
Calamagrostis spp.	0			0.251
Agropyron spp.	0			0.276
Danthonia spp.	0			-0.112
Festuca spp.	-			- .064
Koeleria crist.	0			0.205
Stipa spp.	0			- .039
Other				
2nd Major Grass		.007	.010	
None	0			-0.388
Calamagrostis spp.	0			.039
Agropyron spp.	0			.001
Danthonia spp.	0			0.121
Festuca spp.	0			-0.201
Koeleria crist.	0			-0.127
Stipa spp.	0			- .025
Other	-			-0.219
Density of Forest Under		.026	.016	
0%	0			-0.194
1 -20	0			- .017
21 -40	+			0.317
41 -60	0			- .088
61 -80	+			.012
81+	0			- .057
Not in forest	-			
Amount of Grassland Duff				
0%	0			
1 -20	0			
21 -40	0			
41 -60	0			
61 -80	0			
81 -100	0			
Not on grassland	+			
Potentilla fru. Cover		.009	.006	
0 per 45 m^2	-			.020
1 - 5	0			0.113
6 -10	0			0.176
11 -20	0			-0.164
21 -30	0			.069
30+	0			-0.290
Not on grassland	0			

	Direction of Response	eta	beta	MCA Coefficient
Forest Deadfall		.034	.066	
0%	0			.005
1 -20	+			0.252
21 -40	-			- .020
41 -60	0			0.116
61 -80	-			-0.162
81+	0			-0.308
Not in forest	-			
Distance to Grassland		.007	.005	
0 metres	-			- .086
1 -20	0			-0.116
21 -50	0			-0.127
51 -100	0			.034
101 -200	+			.042
200+	0			.005
Distance to Cover		.007	.013	
0 metres	0			0.197
1 -20	0			0.275
21 -50	0			- .041
51 -100	-			0.117
101 -200	0			.063
200+	0			- .047
Slope		.006	.009	
0 -10°	0			.046
11 -20	0			.006
21 -30	0			-0.128
30+	0			-0.278
Aspect				
No slope	0			
N	0			
S	+			
E	0			
W	0			

Based on X^2 tests with the hypothesis that occurrance of fecal groups follow expected patterns ($p \leq .05$) (+ = sign occurs more frequently than expected; 0 = sign occurs as frequently as expected, or category too small for calculation of confidence intervals; - = sign occurs less frequently than expected).

Table . Summer Response of Elk to individual features of habitat.

Multiple Relationships: Generalized R^2 = .13 ; Multiple R = .22 ; Multiple R^2 = .05

	Direction of Response	eta	beta	MCA Coefficient
Conifer Cover				
None	-			
1 - 5%	+			
6 -25	+			
26 -50	0			
51 -75	0			
76+	0			
Deciduous Cover				
None	-			
1 - 5%	0			
6 -25	0			
26 -50	0			
51 -75	0			
76 -100	0			
Tree Cover		.011	.010	
None	-			- .071
1 -10%	0			- .052
11 -25	+			- .011
26 -50	0			.114
50+	0			.281
1st Major Tree		.029	.037	
None	0			.171
Populus trem.	0			- .112
P. balsam.	0			- .187
Picea glauca	-			- .299
Pinus contorta	+			.092
2nd Major Tree		.014	.012	
None	-			- .071
Populus trem.	0			.113
P. balsam.	0			- .042
Picea glauca	0			.011
Pinus contorta	+			.190
Shrub Cover		.019	.011	
None	0			- .263
1 - 5%	0			.020
6 -25	+			.006
26 -50	0			- .087
51 -75	0			- .056
76+	-			- .205
1st Major Shrub		.021	.014	
None	0			- .255
Rosa spp.	0			- .004
Symphoricarpos spp.	0			- .055
Shepherdia canad.	+			.313
Eleagnus com.	0			- .112
Amelanchier alni.	0			- .037
Potentilla fru.	0			- .078
Picea glauca	0			- .098
Other	0			.174
2nd Major Shrub		.011	.003	
None	0			.021
Rosa spp.	0			.038
Symphoricarpos spp.	0			- .052
Shepherdia canad.	0			- .058
Eleagnus com.	0			- .158
Amelanchier alni.	0			.098
Potentilla fru.	0			- .033
Picea glauca	0			- .038
Other	0			.007
Herb Cover		.014	.012	
None	0			- .377
1 - 5%	0			- .139
6 -25	0			.023
26 -50	0			.030
51 -75	0			.034
76+	0			- .093
Grass Cover		.017	.015	
None	0			- .104
1 - 5%	0			- .110
6 -25	0			.014
26 -50	0			- .005
51 -75	+			.153
76+	0			.204

Table continued.

	Direction of Response	eta	beta	MCA Coefficient
1st Major Grass		.007	.009	
None	0			.027
Calamagrostis spp.	0			.103
Agropyron spp.	0			.019
Danthonia spp.	0			- .150
Festuca spp.	0			- .351
Koeleria crist.	0			- .0152
Stipa spp.	0			- .188
Other	0			
2nd Major Grass				
None	0			
Calamagrostis spp.	0			
Agropyron spp.	0			
Danthonia spp.	0			
Festuca spp.	0			
Koeleria crist.	0			
Stipa spp.	0			
Other	0			
Density of Forest Under				
0%	0			
1 -20	+			
21 -40	+			
41 -60	0			
61 -80	0			
81+	0			
Not in forest				
Amount of Grassland Duff		.009	.012	
0%	0			.043
1 -20	+			.018
21 -40	0			.013
41 -60	0			- .121
61 -80	0			- .316
81 -100	0			1.518
Not on grassland	+			.021
Potentilla fru. Cover				
0 per 45 m^2	-			
1 - 5	0			
6 -10	0			
11 -20	0			
21 -30	0			
30+	0			
Not on grassland	+			

	Direction of Response	eta	beta	MCA Coefficient
Forest Deadfall				
0%	0			
1 -20	0			
21 -40	0			
41 -60	0			
61 -80	-			
81+	-			
Not in forest	-			
Distance to Grassland		.007	.003	
0 metres	0			- .085
1 -20	0			- .033
21 -50	0			- .068
51 -100	+			.064
101 -200	0			.037
200+	0			- .038
Distance to Cover		.007	.003	
0 metres	0			.021
1 -20	0			.087
21 -50	0			- .138
51 -100	0			.029
101 -200	0			.082
200+	0			- .002
Slope		.006	.016	
0 -10°	0			.065
11 -20	0			- .008
21 -30	0			- .169
30+	0			- .314
Aspect		.007	.020	
No slope	+			- .187
N	0			- .002
S	+			.157
E	0			.077
W	0			- .133

Based on X^2 tests with the hypothesis that occurrance of fecal groups follow expected patterns ($p \leq .05$) (+ = sign occurs more frequently than expected; 0 = sign occurs as frequently as expected, or category too small for calculation of confidence intervals; - = sign occurs less frequently than expected).

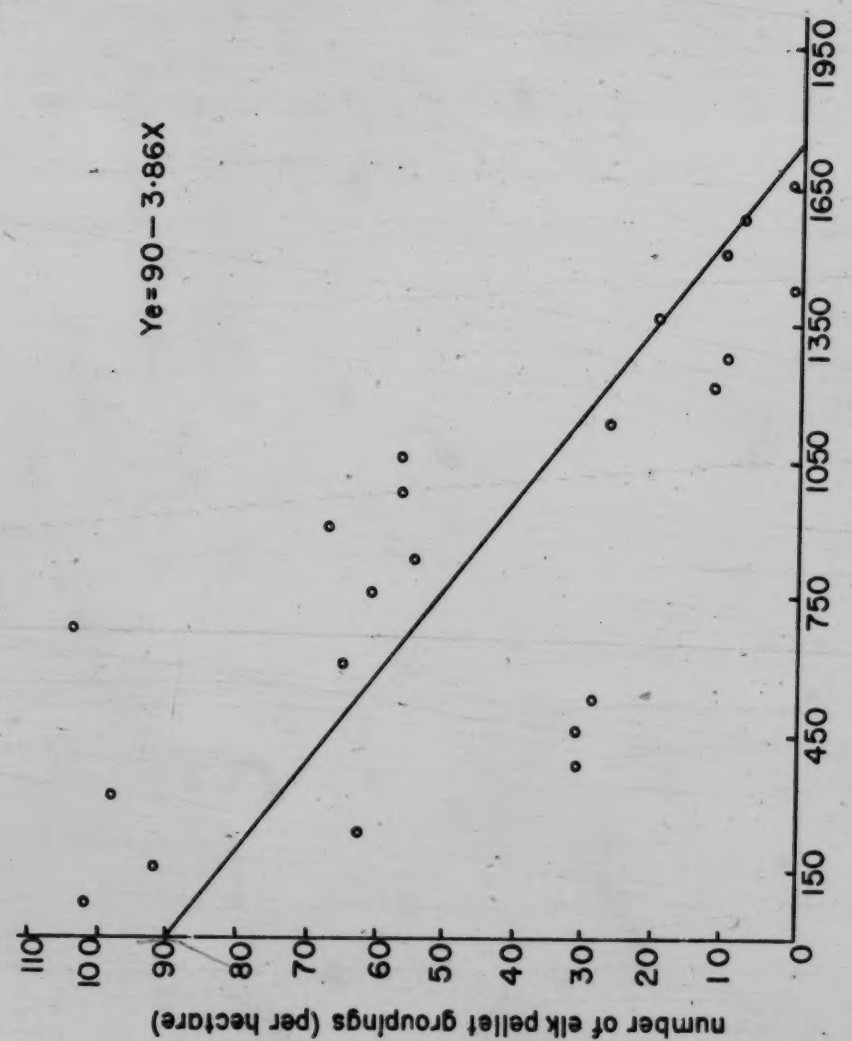


Figure 1. Distance elk moved out of the park in winter of 1977/78.

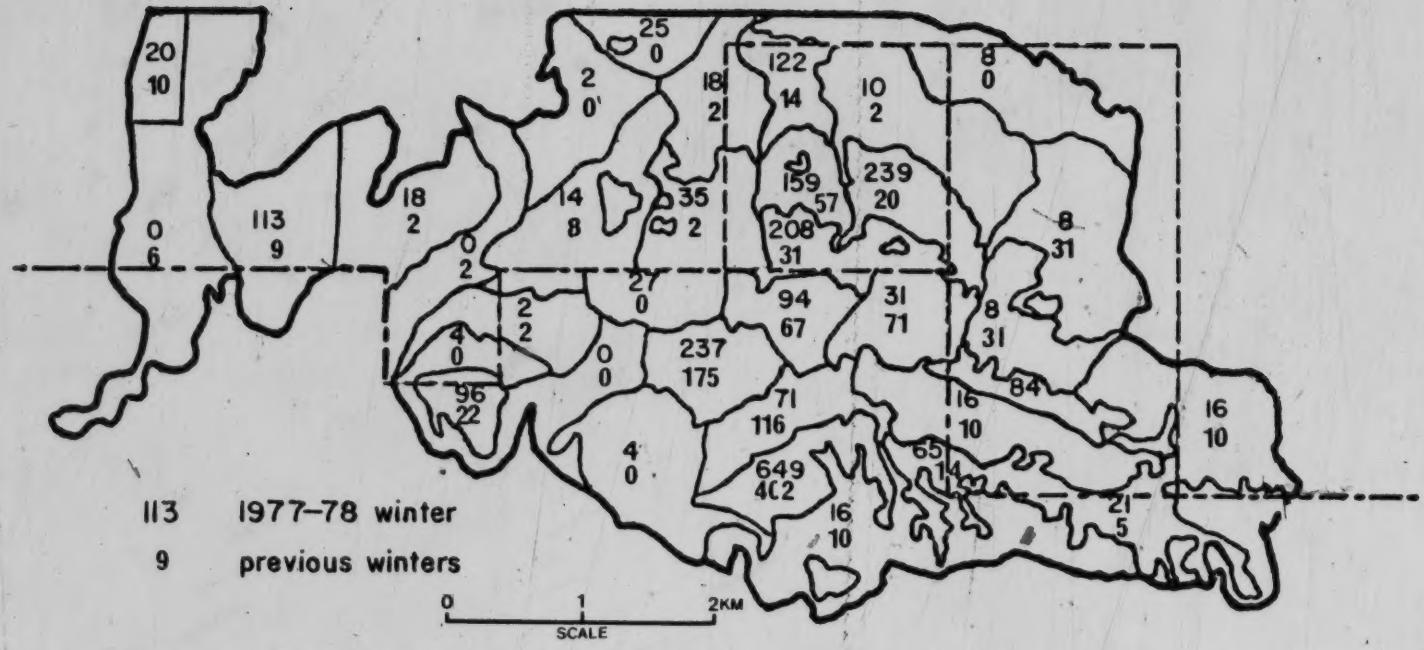


Figure 2. Elk pellets/ha for elk winter range - 1976/77 and 1977/78.

Appendix B

Forage and Feeding

List of Tables

1. R^2 values for various transformations on twig measurements.
2. Values of constants for the prediction equations of 8 shrub species.
3. Location of browse and fecal group transects.
4. Standing crop and utilization from 18 plots in 1977.
5. Production and utilization from 43 plots in 1978.

BROWSE PRODUCTION STANDING CROP AND UTILIZATION

Techniques described for browse standing crop, productivity and utilization are those of Cottam and Curtis (1956) and Telfer (1969) as have been used in Elk Island National Park (Telfer, 1972).

The initial selection and establishment of sites for transect lines was done by Parks Division of Alberta Parks, Recreation and Wildlife in the spring of 1977. The lines were selected from 1:12,000 aerial photos of the entire Park and minor changes made after field checking. Effort was made to ensure sufficient representation of the various cover types within the suspected important ranges of wild ungulates and considered also accessibility and obstacle avoidance (i.e. creeks, cliffs, etc.). Each of the twelve transects consisted of twenty sampling points (±3) spaced twenty metres apart for a total of 380 m. The location of the twelve transects is shown in Fig. 3.1.

The point centred quarter method (Cottam and Curtis, 1956) was used by Parks in the spring of 1977 to determine densities of various browse species for different areas of the Park. Sample points and browse species within each quarter were permanently marked with an identification tag

in order to permit annual re-sampling by future researchers. Within each quarter, true bearings and distance were measured from the sample point to the nearest stem of a browse species which was greater than 1 dm high and less than 4 cm diameter at breast height (1.5 m). Species of browse plant, stem length and diameter at ground level was recorded to facilitate location of stems if tags were lost. All twigs longer than 2 - 3 cm in length and occurring between 1.0 and 2.5 m in height were counted. Counts were made of all unbrowsed twigs and all twigs browsed during the previous winter, differentiating those browsed by ungulates and those browsed by snowshoe hare. The predominant cover type of each sample point was recorded. The data sheet for recording of this information is shown in Appendix E.

In spring, 1978, I re-sampled the transects to determine indications of range trend of browse species and to correlate this data with information on twig weight - diameter relationships. Estimations of twig weights were made on eight species of browse plants subjectively chosen. These species included Amelanchier alnifolia, Cornus stolonifera, Eleagnus commutata, Populus tremuloides, Salix spp., Shepherdia canadensis, Rosa acicularis and Symphoricarpos occidentalis. 50-100 measurements of diameter at the base of the previous year's growth (called diameter of current growth, DCG) and the diameter at the point of

browse (DPB) were made. Measurements were made of both transect and non-transect stems.

Determination of twig-weight diameter relationships were made by collecting twigs of each of the eight browse species throughout the Park. Diameter at the base of the cut twig was measured to give a "green diameter" corresponding to the diameter of the unbrowsed twigs (DCG). These measurements were then used to make weight estimates of last year's yield. The twigs were tagged and air dried indoors for 2 - 4 weeks and the basal diameter again measured and recorded. This measurement corresponded to the diameter at the point of browsing (DPB) (since radical shrinkage does occur at the stubs of browsed twigs. The twigs were oven dried (convection oven) at 70°C for 48 hours and then weighed to the nearest .01 g. Plotted graphs indicated a curvilinear relationship between weight diameter. Consequently, a square root transformation (Telfer 1968) was used to derive a regression equation since it was found to give the highest r^2 values (see Appendix B, Table 1 for a comparison of r^2 values using various transformations).

To determine density of stems the Park was classified into eight vegetational groups, as determined by gross air photo features. These groups are shown in Appendix A, Fig. 3. The data from the transects (or parts thereof) were

classified within an appropriate vegetational group.

Transects V and P into group 1A (scattered grassland), transect O into groups 2, 3, 4 (30 - 50% deciducus or conifer cover, 50 - 75% deciduous or conifer cover and fairly continucus cover with frequent openings), transect I intc group 5 (deciudous cover with or without scattered pine or spruce), transects W, I, P and A into group 6 (mixed forest with fairly even distributicn of deciduous or conifer), transects N and E intc group 7 (coniferous forest with or without scattered deciduous), and transects D and F into groups 8 and 9 (closed canopy coniferous forest and dense pine - cld burn).

Withir each grouping the number cf stems per hectare was calculated by:

$$\frac{10{,}000}{d^2}$$

where d = sum of distances at each point

total number of distances

The number of stems per hectare for each species in each grouping was determined by:

Salix spp. stems/ha =

(Total number of stems/halx (Number of Salix spp. tallied)

Total number of stems of all species tallied

The previous year's browse production was calculated in each grouping for each species by:

$$\text{Number of unbrowsed twigs} + \text{number of browsed twigs} \times \frac{\text{total number of stems/ha for all species}}{\text{Total number of stems in sample for all species}}$$

The mean weight of twigs is obtained from the plotted relationships of weight - diameter for DCG's. The determination of mean twig weight for each species is calculated by a weighted mean DCG:

$$\sqrt{\frac{\sum_{i}^{n} X_i^2}{n}}$$

where X is the DCG measurement for ith twig of that species and n is the total number of measurements. It is this value that is used to determine the mean oven-dried twig weight for each species from the regression equations.

The above procedure was repeated using the DPE measurements in order to calculate the weight of the browsed material.

Table 1. R^2 values for various transformations on 1978 twig measurements.

		No Transformation	LN	LN/LN	SQRT
Amelanchier alnifolia	(green) DCG	.63461	.71286	.70521	.70808
"	(dry) DPB	.53430	.61010	.59959	.60181
Cornus stolonifera	(green) DCG	.67505	.77722	.82978	.88118
"	(dry) DPB	.73338	.77827	.85883	.91545
Eleagnus commutata	(green) DCG	.71263	.69855	.70712	.72119
"	(dry) DPB	.62937	.64798	.64108	.65170
Populus tremuloides	(green) DCG	.66530	.64297	.64929	.67182
"	(dry) DPB	.60408	.59551	.60433	.61632
Rosa arkansana/woodsia	(green) DCG	.65946	.72397	.69207	.72398
"	(dry) DPB	.61338	.68321	.65911	.67904
Salix spp.	(green) DCG	.73470	.83874	.84745	.85579
"	(dry) DPB	.72650	.81888	.83821	.84456
Shepherdia canadensis	(green) DCG	.70270	.74476	.73551	.78538
"	(dry) DPB	.67256	.77300	.77479	.78976
Symphoricarpos occidentalis	(green) DCG	.70782	.84046	.84147	.81034
"	(dry) DPB	.69195	.82597	.82493	.79139
Averages		.66861	.73203	.73805	.75299

Table 2 . Values of constants for the prediction equations for twigs of 8 woody plant species. (Prediction equation is of the form: SQRT weight = a + b (diameter).

Species		Constants a	Constants b	Range of twig diam. in sample (mm)	R^2	Sample Size	Wghted. diam. (mm)	Wght. (g)
Amelanchier alnifolia	(green) DCG	-.220	.286	1.5 - 4.7	.70808	100	3.1	.44
"	(dry) DPB	-.129	.283	1.5 - 4.0	.60181	100	2.1	.22
Cornus stolonifera	(green) DCG	-.633	.39877 .500	1.4 - 7.3	.88118	76	3.2	.94
"	(dry) DPB	-.614	.552	1.2 - 7.0	.91545	76	2.4	.51
Eleagnus commutata	(green) DCG	-.154	.238	2.0 - 3.3	.72119	91	3.3	.40
"	(dry) DPB	-.032	.213	1.7 - 3.2	.65170	91	2.6	.27
Populus tremuloides	(green) DCG	-.024	.183	1.6 - 5.5	.67182	100	4.2	.55
"	(dry) DPB	.009	.187	1.5 - 4.9	.61632	100	2.4	.21
Rosa arkansana/woodsia	(green) DCG	-.249	.316	1.6 - 4.0	.72398	67	2.2	.20
"	(dry) DPB	-.272	.366	1.5 - 3.3	.67904	67	1.5	.08
Salix spp.	(green) DCG	-.667	.473	1.5 - 6.7	.85579	73	4.0	1.5
"	(dry) DPB	-.621	.488	1.5 - 6.2	.84456	73	2.8	.56
Shepherdia canadensis	(green) DCG	-.167	.269	1.5 - 5.3	.78538	94	2.8	.34
"	(dry) DPB	-.365	.403	1.3 - 5.5	.81034	94	1.8	.13
Symphoricarpos occidentalis	(green) DCG	-.365	.402	1.6 - 4.2	.81034	80	2.9	.65
"	(dry) DPB	-.379	.450	1.4 - 3.9	.79139	80	1.8	.18

Table 3 . Location of browse transects and fecal group transects.

BROWSE TRANSECTS			FECAL GROUP TRANSECTS					
Transect #	Start (UTM) Grid	Bearing from TN	Transect #	Start (UTM) Grid	Bearing from TN	Transect #	Start (UTM) Grid	Bearing from TN
A	441960	0°	1	630011	156°	17	618017	23°
B	449964	86°	2	621014	160°	18	660010	355°
D	507958	303°	3	613011	205°	19	685013	13°
E	657962	235°	4	595011	320°	20	641994	327°
I	711976	220°	5	602012	373°	21	662997	333°
L	533012	74°	6	614020	370°	22	690005	346°
N	570014	209°	7	618015	212°	23	673993	357°
O	583000	90°	8	632013	97°	24	663995	4°
P	615992	40°	9	616022	42°	25	664963	300°
R	628998	65°	10	608015	352°	26	711984	323°
V	642020	47°	11	607023	352°	27	712977	108°
W	588031	180°	12	602010	156°	28	685955	50°
			13	626014	42°	29	712961	354°
			14	599013	343°	30	698943	352°
			15	598022	343°	31	699933	352°
			16	625012	16°	32	708943	170°

Table 4 . Standing crop and utilization from 18 plots in 1977.

	Ungrazed (g/m^2)	Grazed	% Utilized	Location (UTM Grid)
1.	735.7	459.2	37.6	615020
2.	364.1	242.8	33.3	612017
3.	391.3	361.8	7.5	611018
4.	319.5	273.2	14.5	609018
5.	203.6	29.4	85.6	626013
6.	137.4	36.1	73.8	627012
7.	198.9	159.2	20.0	627015
8.	184.6	90.0	51.3	616015
9.	197.1	148.2	24.8	617016
10.	341.4	338.2	0.9	618018
11.	34.1	8.7	74.6	615012
12.	323.6	256.3	20.8	599012
13.	201.4	209.1	0	599015
14.	96.3	43.4	55.0	601010
15.	102.7	38.2	62.4	692952
16.	45.2	39.9	11.8	691954
17.	10.5	2.1	79.4	693949
18.	28.3	16.0	42.5	694947

Table 5 . Production and utilization from 43 plots in 1978.

	g/m²		%	Location		g/m²		%	Location
	Ungrazed	Grazed	Utilized	(UTM Grid)		Ungrazed	Grazed	Utilized	(UTM Grid)
1	255.3	224.3	12.1	615020	23	226.6	220.7	2.6	660020
2	269.7	242.6	10.1	612017	24	-	-	-	658025
3	317.0	215.9	31.9	611018	25	222.5	155.4	30.2	672994
4	257.8	223.8	13.2	609018	26	202.9	170.9	15.8	672995
5	173.2	83.3	51.9	626013	27	328.7	236.5	28.0	671998
6	-	-	-	627012	28	194.6	179.6	7.7	653994
7	190.2	170.7	10.3	627015	29	186.2	163.1	12.4	653998
8	230.1	251.5	0	616015	30	298.5	332.0	0	683012
9	223.0	211.3	5.2	617016	31	337.3	118.9	64.8	683014
10	180.8	176.0	2.7	618018	32	128.3	133.1	0	685015
11	-	-	-	615012	33	173.2	150.9	12.9	685017
12	377.2	263.1	30.2	599012	34	192.8	150.6	21.9	568998
13	245.4	227.8	7.1	599015	35	190.5	134.9	29.2	552961
14	-	-	-	601010	36	436.1	297.7	31.7	495983
15	150.1	129.5	13.7	692952	37	376.4	223.5	40.6	462969
16	165.1	147.6	10.6	691954	38	282.2	222.0	21.3	449965
17	181.4	82.3	54.6	693949	39	124.2	102.4	17.6	679965
18	153.7	101.9	33.7	694947	40	-	-	-	68065
19	111.8	89.2	20.2	694943	41	170.9	129.4	24.3	678967
20	190.8	161.0	15.6	669019	42	153.9	127	17.5	675968
21	266.4	192.3	22.7	668023	43	167.4	117.3	29.9	673969
22	312.7	173.2	44.6	662024					

- no data - exclosure cone was disturbed.

Appendix C

Resource Partitioning of Moose and Deer

List of Tables

1. Percentage similarities and rank correlations of moose and deer diets

2. Values of spatial relationships between moose and deer.

3. Indices of overlap in spatial distribution, habittat selection and food habits of moose and deer.

Table 1 . Percentage similarities and rank correlations of moose and deer diets.

Species and Season	% Similarity	Spearmans RHO
Total Moose & Total Deer	54	.38
Spring/Summer Moose & Spring/Summer Deer	67	.56
Fall/Winter Moose & Fall/Winter Deer	39	.48

Table 2 . Values of spatial relationships between moose and deer.

Species and Season	Spatial Overlap	Coincidence Index	Association Index	Interspecific Crowding	Habitat Overlap
Total Moose	1.28	.19	.30	.45	1.03
Total Deer			.14	.19	
Spring/Summer Moose	.73	.08	.10	.14	.87
Spring/Summer Deer			.05	.05	
Fall/Winter Moose	1.46	.14	.20	.25	.98
Fall/Winter Deer			.11	.14	

Table 3 . Indices of overlap in spatial distributions, habitat selection and food habits between Moose and Deer.

Species and Season	Spatial Distributions (S)	Habitat Selection (H)	Distributional Overlap (S x H)	Food Habits (F)	Niche (SxHxF) product	Overlap (S+H+F)/3 summation
Total Moose & Total Deer	.14	.63	.09	.54	.05	.45
Spring/Summer Moose & Spring/Summer Deer	.05	.25	.01	.67	.01	.32
Fall/Winter Moose & Fall/Winter Deer	.11	.31	.03	.39	.01	.27

Appendix D

Selected Formulae

Table 1 . Selected formulae and statistical notations used in analysis of food habits and habitat utilization.

Notation	Location in Text (Page)	Explanation
R^2	67	Generalized squared multiple regression coefficient indicating the proportion of variance explained by the Multiple Classification Analysis models.
Eta^2 (MCA)	61	One-way analysis of variance coefficient indicating the bivariate relationship (explained variance) between the dependent variable and each predictor variable.
$Beta^2$ (MCA)	61	Experimental statistic indicating the predictive power (explained variance) of each independent variable while controlling for all others.
Degree of Selectivity (Patchiness)	59	Calculated as $G' = (n/X^2) \sum_i (x_i(x_i - 1))$, and $G' = n/Y^2 \sum_i (y_i(y_i - 1))$, where n = number of samples (plots), x_i = number of individuals in each sample of species x, y_i = number of individuals in each sample of species y.
Intraspecific Crowding	59	Calculated as $\overset{*}{m} = x_i(x_i - 1)/X$ and $\overset{*}{m} = y_i (y_i - 1)/Y$, where x_i and y_i are the number of individuals in species x and y respectively, X and Y are the total number of individuals in species x and y respectively.
Distributional Uniformity (Niche breadth)	59	Calculated as $B = 1/n \quad Px_i^2$, and $B = 1/n \sum_i Py_i^2$, where $Px_i = x_i/X$, $Py_i = y_i/Y$.
Habitat Overlap (Niche overlap)	155	Calculated as $A/XY \sum_i x_i y_i/a_i$, where A = total abundance of resource states, X = number of individuals of first species,

		Y = number of individuals of second species, x_i = number of individuals in the ith sample of the first species, y_i = number of individuals in the ith sample of the second species, a_i = abundance of the ith resource state.
Spatial Overlap	155	Calculated as $L = n \sum_i (Px_i Py_i)$, symbols same as Distributional Uniformity.
Coincidence Index	154	Calculated as $2h/a + b$, a = the number of samples (plots) in which species A occurs, b = the number of samples in which species B occurs, h = the number of samples in which A + B occur together.
Association Index	154	Calculated as $A/B = h/b$ and $B/A = h/a$, symbols same as for Coincidence Index.
Interspecific Crowding	154	Calculated as $Zx(y) = \sum_i (x_i y_i/X)$ and $Zy(x) = \sum_i (x_i y_i/Y)$, symbols same as for Degree of Selectivity.
Similarity Coefficient	153	Calculated as $c = 2w/(a + b) \times 100$, where w = sum of the lowest percentage composition values of species or species groups common to two diets, and a and b are the total percentage values of all species in the diets.
Spearmans RHO	155	Calculated as $r_s = 1 - 6(\sum_i di^2)/N (N^2 - 1)$ where di = total difference between ranked species, N = total number of samples (species of species groups). Significance was tested by $t = r_s/N - 2/1 - r_s^2$.

Affinity Index	59	Calculated as percent of fecal piles in that type (canopy cover or vegetation association) divided by percent of transect plots in that type.
Coefficient of Association	153	Calculated as (ad - bc/ ad - bc) /((ObsX^2 - MinX^2)/(MaxX^2 - MinX^2)) where a, b, c and d refer to the four cells of a 2 x 2 contingency table, ObsX^2 is the value of X^2 associated with the values of a, b, c and d, Max^2 is the value of X^2 when a is as large (if ad bc) or as small (if ad bc) as the marginal totals of the 2 x 2 table permit and MinX^2 is the value of X^2 when the observed value of a differs from a, the expected value of a, by less than 1.00.
Overlap (Space, Habitat and Food)	155	Calculated as $\sum_{i}^{n} = Y_i$, where Y_i is the lowest percentage value common to two species.

Appendix E

Data Sheets

Ungulate Browse Survey

Cypress Hills Provincial Park

: _____

Plot #	Stand Type	Aspect	Stem #	Species	Brg.	Dist. (m)	Basal Diam. (cm)	Stem Length (cm)	# of Twigs			# of Pellet-groups			
									unbrow.	U. brow.	H. brow.	Moose	Deer	Elk	Cattle
			1												
			2												
			3												
			4												
			1												
			2												
			3												
			4												
			1												
			2												
			3												
			4												
			1												
			2												
			3												
			4												
			1												
			2												
			3												
			4												

- 1977: June _____ Transect: _____ Type:
August_____ Plot: _____
1978: June _____ Bearing: _____
August_____

FECES 77J	77A	78J	78A

SLOPE ASPECT DEADFALL LITTER REMARKS
Macro _____ Macro _____
Micro _____ Micro _____

DISTANCE TO NEXT DIFFERENT TYPE	N TYPE	S TYPE	E TYPE	W TYPE

TREES NO. DBH HGHT

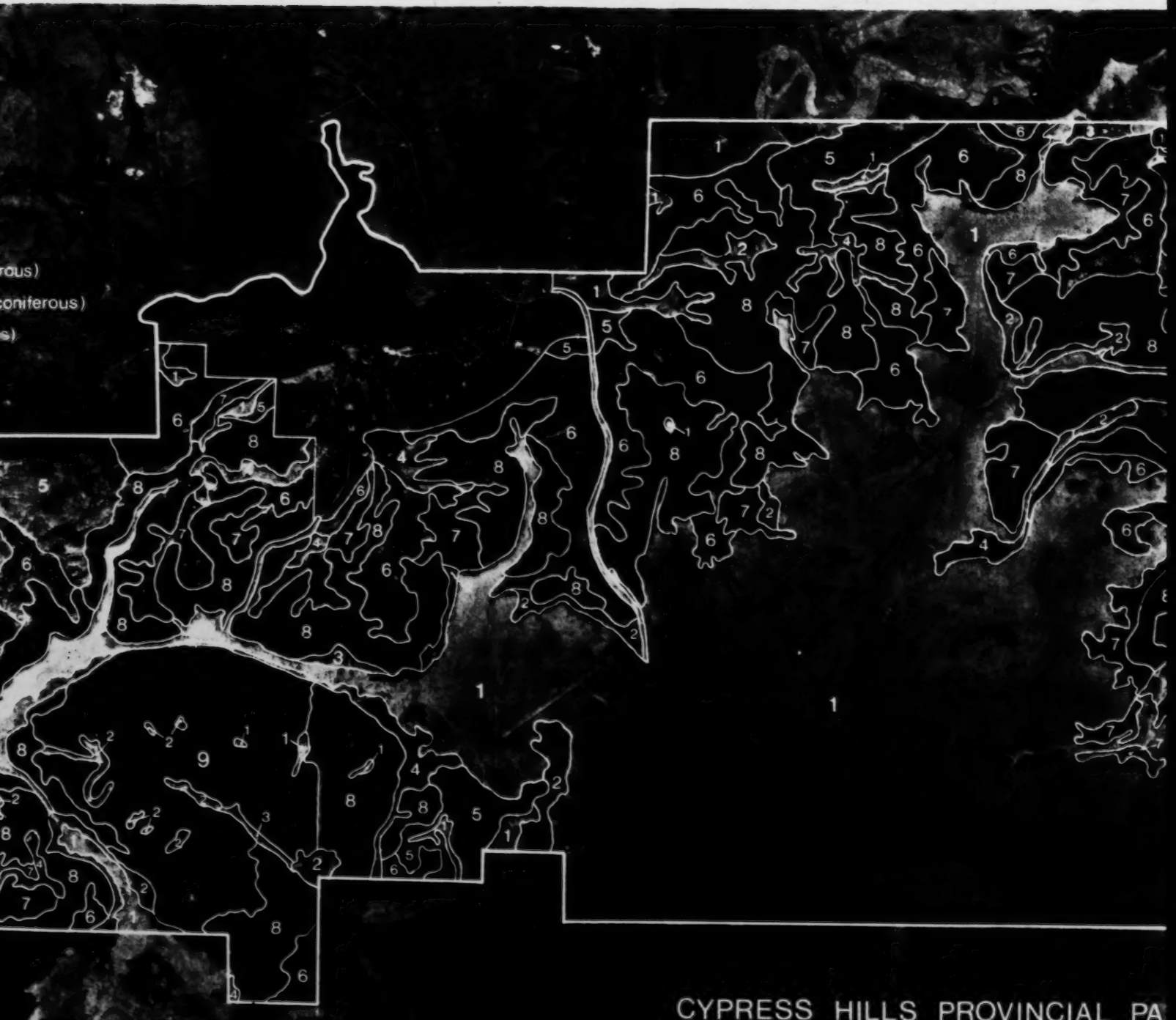
HERBS

SHRUBS COVER

GRASSES COVER

COVER TYPE
1. Grassland (up to 33% tree cover)
2. 34 - 50 % tree cover (deciduous or coniferous)
3. 51 - 75% tree cover (deciduous or coniferous)
4. Continuous forest cover with frequent openings
5. Deciduous forest (with or without scattered coniferous)
6. Mixed forest (even distribution of deciduous and coniferous)
7. Conifer forest (with or without scattered deciduous)
8. Closed canopy coniferous forest
9. Closed canopy coniferous forest (old burns)

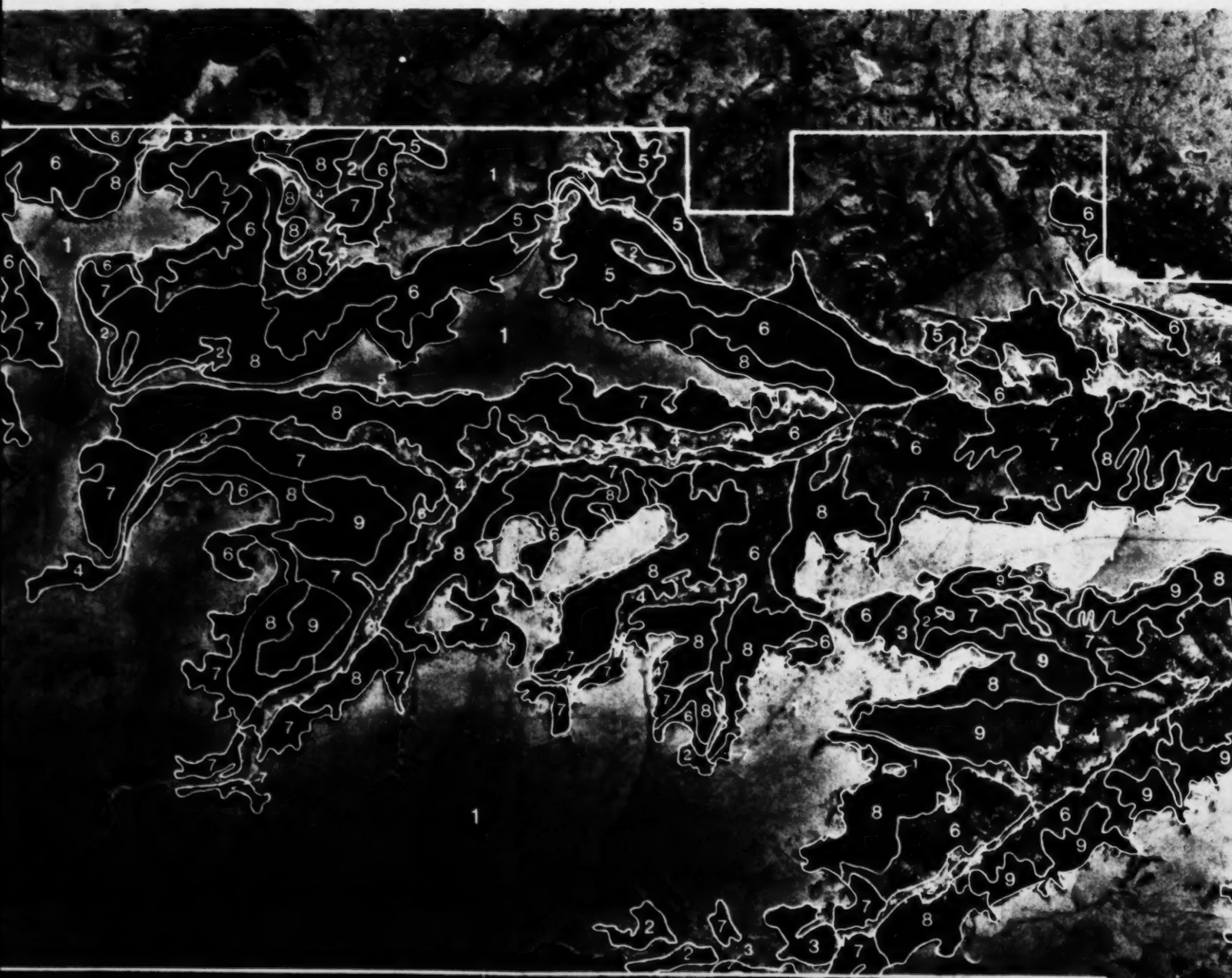
20



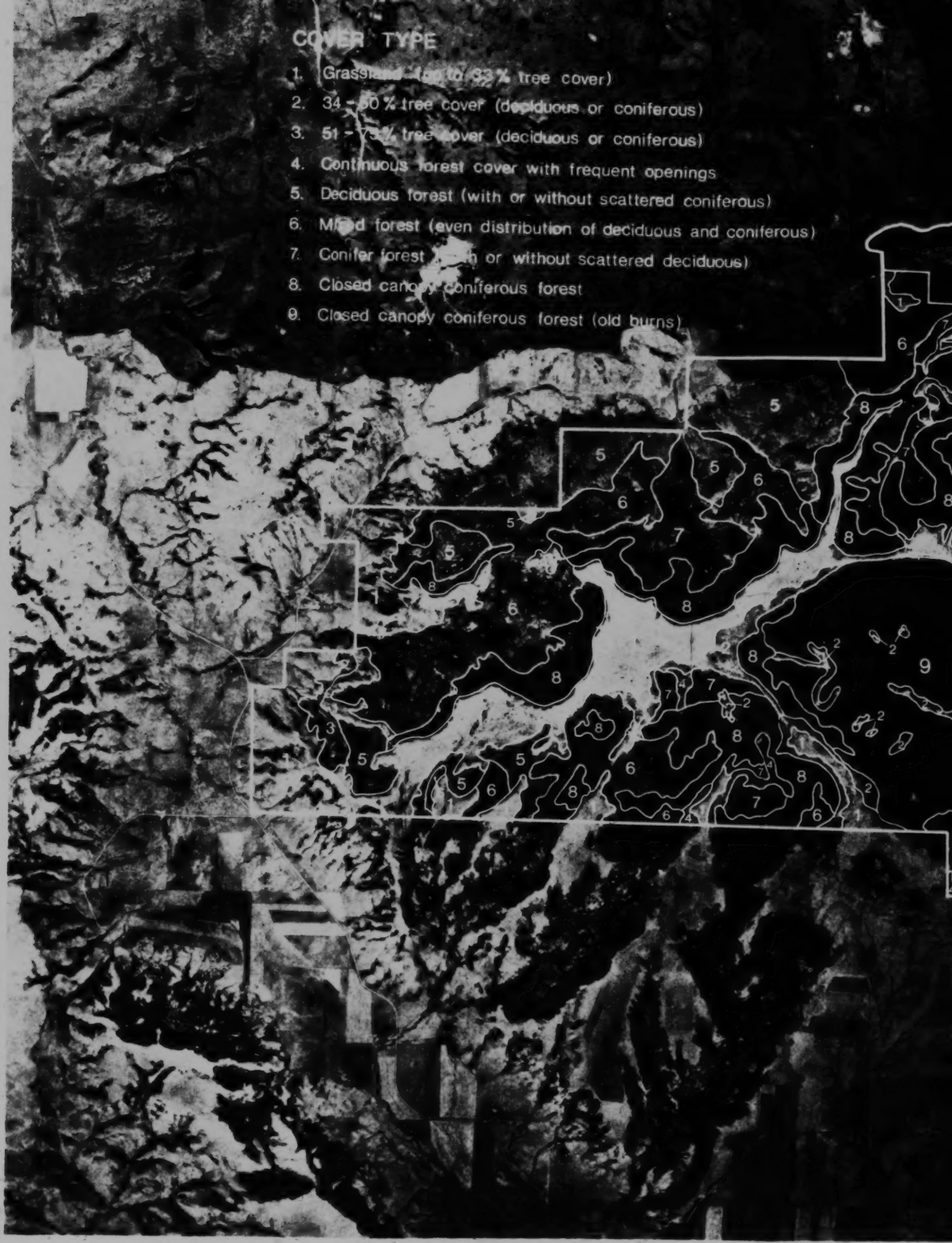
CYPRESS HILLS PROVINCIAL PA

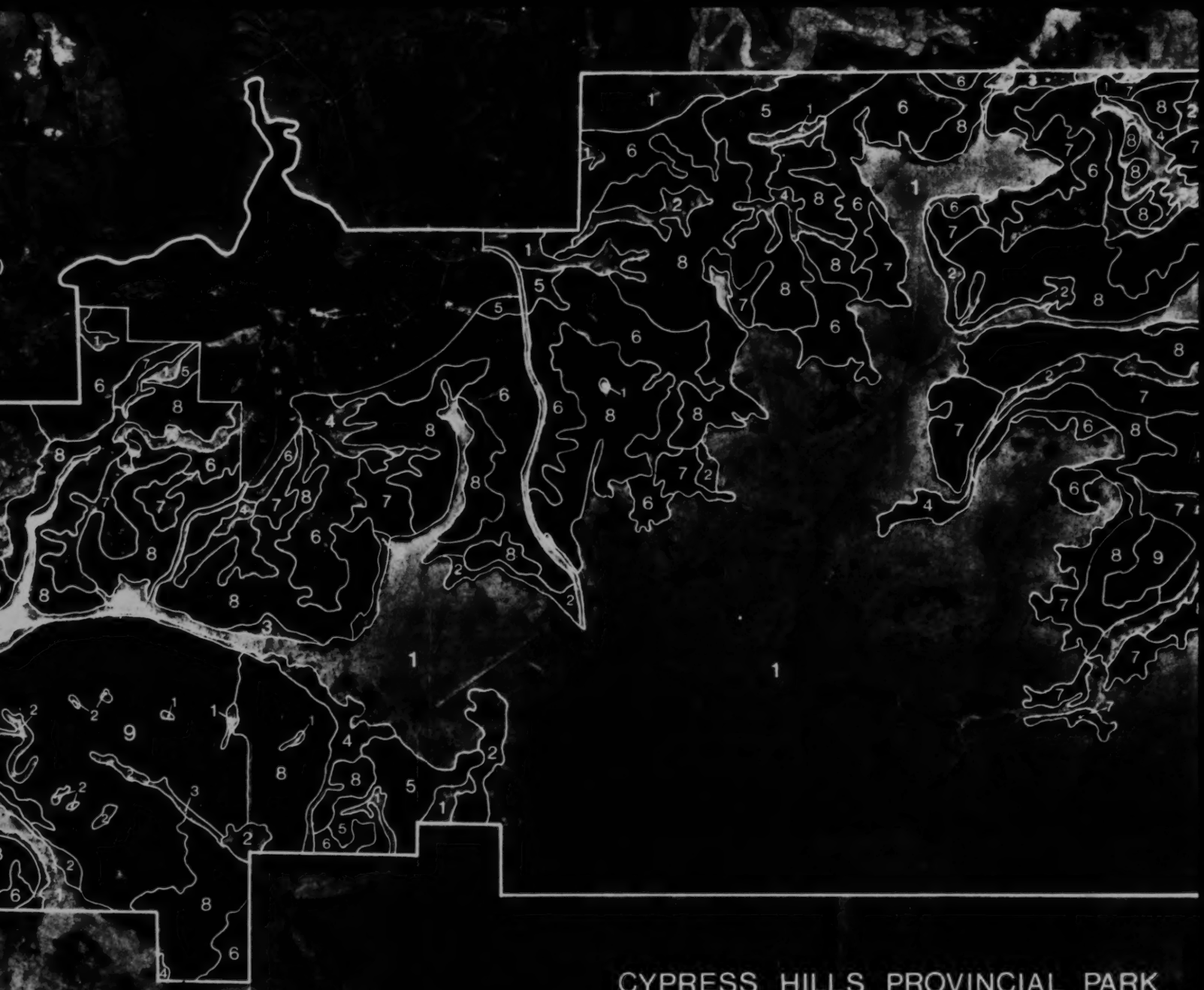
Major Cover Types

Scale 1:50000



S PROVINCIAL PARK


COVER TYPE
1. Grassland (up to 33% tree cover)
2. 34 - 50% tree cover (deciduous or coniferous)
3. 51 - 75% tree cover (deciduous or coniferous)
4. Continuous forest cover with frequent openings
5. Deciduous forest (with or without scattered coniferous)
6. Mixed forest (even distribution of deciduous and coniferous)
7. Conifer forest (with or without scattered deciduous)
8. Closed canopy coniferous forest
9. Closed canopy coniferous forest (old burns)

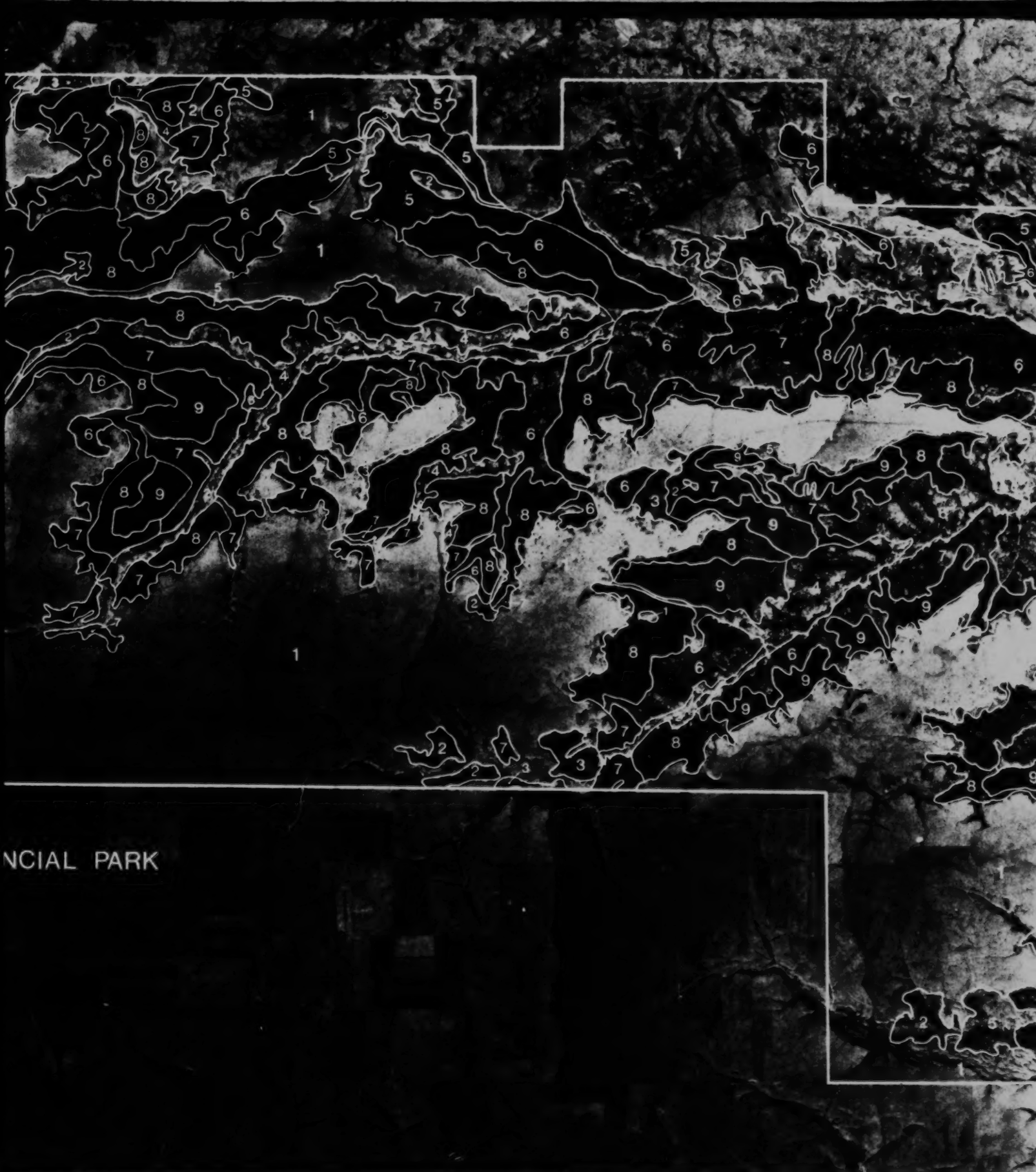


CYPRESS HILLS PROVINCIAL PARK

Major Cover Types

Scale 1:50000

60/ 1



NCIAL PARK

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